Water Quality Improvement Plan
for
Upper Chariton River

Clark, Lucas, Monroe, Decatur, Wayne, and Appanoose Counties, Iowa

Total Maximum Daily Loads for:
Pathogen Indicators (*E. coli*)

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2020

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List of Abbreviations

Units of measure:

ac	acre	mi	mile
cfs	cubic feet per second	mL	milliliter
cfu	colony-forming unit	mo	month
cm	centimeter	mt	metric ton (= 1 Mg)
cms	cubic meters per second	orgs	E. *coli* organisms
d	day	ppm	parts per million
g	gram	ppb	parts per billion
ha	hectare	s	second
hm	hectometer	t	ton (English)
hr	hour	yd	yard
in	inch	yr	year
kg	kilogram		
km	kilometer		
L	liter		
lb	pound		
m	meter		
mg	milligram		
Mg	megagram (= 1 mt)		

Other abbreviations:

AFO	animal feeding operation
BMP	best management practice
Chl-a	chlorophyll *a*
E. coli	Escherichia coli
GM	geometric mean (pertains to WQS for *E. coli*, = 126 orgs/100 mL)
LDC	load duration curve
N	nitrogen
ortho-P	ortho-phosphate
P	phosphorus
SSM	single-sample max (pertains to WQS for *E. coli*, = 235 orgs/100 mL)
TN	total nitrogen
TP	total phosphorus
WQS	water quality standard

General Report Summary

What is the purpose of this report?
This report serves multiple purposes. First, it is a resource for increased understanding of watershed and water quality conditions in the Upper Chariton River watershed. Second, this report satisfies the Federal Clean Water Act requirement to develop a Total Maximum Daily Load (TMDL) report for all impaired 303(d) waterbodies. Third, it provides a foundation for locally-driven water quality improvements to the Upper Chariton River watershed in an effort to improve water quality. Finally, it may be useful for obtaining financial assistance to implement projects in the Upper Chariton River watershed that will eventually result in water quality improvements to justify removal from the federal 303(d) list of impaired waters.

What is wrong with the Upper Chariton River?
Six main stem stream segments in the Upper Chariton River and nine of its tributaries are not supporting the primary contact recreation "designated use" due to high levels of indicator bacteria called Escherichia coli (*E. coli*). Primary contact recreation includes activities that involve direct contact with the water such as swimming and wading. High *E. coli* levels in the water can indicate the presence of potentially harmful bacteria and viruses (also called pathogens) that can cause humans to become ill if they come into contact with and/or ingest contaminated water.

What is causing the problem?
E. coli and harmful pathogens found in a waterbody can originate from point or nonpoint sources of pollution, or a combination of both. Point sources of pollution are easily identified sources that enter a waterbody at a distinct location, such as a wastewater treatment plant discharge. Nonpoint sources of pollution are discharged in a more indirect and diffuse manner, and are often more difficult to locate and identify. Nonpoint source pollution is usually carried with rainfall or snowmelt over the surface of the land and into the waterbody.

Both point and nonpoint sources of pollution can be responsible for high *E. coli* levels. Permitted sources include municipal wastewater treatment facilities (WWTF) and discharging onsite wastewater treatment and disposal systems. Onsite wastewater treatment systems are often called septic systems, even though not all systems include a septic tank. Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in the watershed. Specific examples of potential nonpoint sources of bacteria include cattle with direct access to streams, manure applied to row crops, non-permitted onsite wastewater systems, and natural sources such as wildlife.

What can be done to improve the Upper Chariton River?
To improve the water in the Upper Chariton River so that primary contact recreation is fully supported, the amount of bacteria entering the stream must be reduced. Accomplishing this will require a combination of land, animal, stormwater, and wastewater management practices. In the rural areas of the watershed, efforts should focus on eliminating livestock access to streams, strategic manure application that considers both timing and application methods, and improving failing onsite wastewater treatment systems to meet state standards.

Urban activities should include the adoption of stormwater BMPs geared specifically to bacteria reduction and / or runoff reduction. This approach includes elimination of sanitary sewer overflows (SSOs) and possible illicit sanitary sewer connections, strategic management of wastewater facility discharges (adjustment of discharge timing, disinfection, etc.). Additionally, public outreach and educational programs such as those encouraging pet owners to pick up pet waste may be helpful.

Who is responsible for a cleaner Upper Chariton River?
Everyone who lives, works, and plays in the Upper Chariton River watershed has a role to play in improving water quality. Because there are several municipal point sources in the watershed, these facilities must meet wasteload allocations (WLAs) that will be incorporated into their National Pollutant Discharge Elimination System (NPDES) permits. Voluntary management of land and animals by private citizens will also be needed to see positive results. The majority of land in the watershed is in agricultural production, and financial assistance is often available from government agencies to individual landowners willing to adopt best management practices (BMPs). Rural homeowners can have

their septic systems inspected to ensure they function properly. Failing or malfunctioning systems should be repaired or replaced. Improving water quality in the Upper Chariton River watershed will require a collaborative effort of citizens and agencies with a genuine interest in protecting the streams and rivers now and in the future.

Does a TMDL guarantee water quality improvement?

The Iowa Department of Natural Resources (Iowa DNR) recognizes that technical guidance and support are critical to achieving the goals outlined in this Water Quality Improvement Plan (WQIP). The WQIP itself is only a document, and without implementation, will not improve water quality. Therefore, a basic implementation plan is included for use by local agencies, watershed managers, and citizens for decision-making support and planning purposes. This implementation plan should be used as a guide or foundation for detailed and comprehensive planning by local stakeholders.

Reducing pollutants from unregulated nonpoint sources requires voluntary implementation of best management practices. Many practices have benefits to sustained productivity of the land as well as water quality. Quantifying the value of sustainability and other ecosystem services is difficult and those benefits are not commonly recognized. Consequently, wide-spread adoption of voluntary conservation practices is often difficult to achieve. A coordinated watershed improvement effort for each individual stream could address some of these barriers by providing financial assistance, technical resources, and information outreach to landowners to encourage and facilitate adoption of conservation practices.

How should this document be used?

Because this document serves several purposes, not everyone will benefit from the entire document. While EPA will be interested in the technical segments that address the TMDL and loading calculations, for stakeholders in and around the Upper Chariton River watershed, the most pertinent information will be found in sections 6 and 7. These sections address what can be done to improve the water quality in the Upper Chariton River.

Required Elements of the TMDL

This Water Quality Improvement Plan has been prepared in compliance with the current regulations for TMDL development that were promulgated in 1992 as 40 CFR Part 130.7 in compliance with the Clean Water Act. These regulations and consequent TMDL development are summarized below.

Name and geographic location of the impaired or threatened waterbody for which the TMDL is being established:	**South Fork Chariton River HUC 10** South Fork Chariton River IA 05-CHA-1328 IA 05-CHA-1327 South Fork Chariton Tributaries Ninemile Creek, IA 05-CHA-1335 Jordan Creek, IA 05-CHA-1330 Jackson Creek, IA 05-CHA-1332 Walker Branch, IA 05-CHA-1329 **Wolf Creek-Chariton River HUC 10** Chariton River IA 05-CHA-1312 IA 05-CHA-1311 IA 05-CHA-1310 Chariton River Tributaries Chariton Creek, IA 05-CHA-1313 Fivemile Creek, IA 05-CHA-1341 Wolf Creek, IA 05-CHA-1339 Honey Creek, IA 05-CHA-1337 Honey Creek, IA 05-CHA-2019 **Cooper Creek-Chariton River HUC 10** Chariton River, IA 05-CHA-1308
Surface water classification and designated uses:	**Class A1 Primary Contact Recreation** All segments listed above **Class B (WW-1) Aquatic Life** Chariton River: IA 05-CHA-1312 and IA 05-CHA-1308 Chariton Creek: IA 05-CHA-1313 Honey Creek: IA 05-CHA-2019 **Class B (WW-2) Aquatic Life** South Fork Chariton River: IA 05-CHA-1328 and IA 05-CHA-1327 Ninemile Creek: IA 05-CHA-1335 Jordan Creek: IA 05-CHA-1330 Jackson Creek: IA 05-CHA-1332 Walker Branch: IA 05-CHA-1329 Fivemile Creek: IA 05-CHA-1341 Wolf Creek: IA 05-CHA-1339 Chariton River: IA 05-CHA-1310 Chariton River: IA 05-CHA-1311 Honey Creek: IA 05-CHA-1337

Impaired beneficial uses:	Class A1 Primary Contact Recreation (March 15 to November 15)
TMDL Priority Level	Tier III
Identification of the pollutant and applicable water quality standards (WQS):	Pathogen Indicator, *E. coli*. Primary contact recreational (Class A1) use is not supported due to violation of the *E. coli* Water Quality Standard criteria of 126 organisms/100 mL for the geometric mean. These standards only apply during the recreational season of March 15 - November 15.
Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards:	The target for the Upper Chariton River segments and its tributaries is a geometric mean of 126 *E. coli* organisms/100 mL. See Table 4.5, Table 4.7, Table 4.9, Table 4.11, Table 4.13, Table 4.15, Table 4.17, Table 4.19 in Section 4.3, Table 5.5, Table 5.7, Table 5.9, Table 5.11, Table 5.13, Table 5.15 in Section 5.3, and Table 6.5 in Section 6.3.
Quantification of the amount or degree by which the current pollutant load in the waterbody, including the pollutant from upstream sources that is being accounted for as background loading, deviates from the pollutant load needed to attain and maintain water quality standards:	The *E. coli* load departure from capacity has been calculated for five flow recurrence intervals for each impaired segment in the watershed for the GM. See Table 4.5, Table 4.7, Table 4.9, Table 4.11, Table 4.13, Table 4.15, Table 4.17, Table 4.19 in Section 4.3, Table 5.5, Table 5.7, Table 5.9, Table 5.11, Table 5.13, Table 5.15 in Section 5.3, and Table 6.5 in Section 6.3
Identification of pollution source categories:	Point sources of bacteria include municipal separate storm sewer systems (MS4s), wastewater treatment facilities (WWTFs), onsite wastewater systems operating under NPDES permits, and sanitary sewer overflows (SSOs). Nonpoint sources of pollution include cattle with direct access to streams, manure application to row crops, failing onsite wastewater treatment systems, and wildlife.
Wasteload allocations (WLA) for pollutants from point sources:	Pathogen Indicator, *E. coli*. The wasteload allocations (WLA) for point sources for each segment are listed in Table 4.6, Table 4.8, Table 4.10, Table 4.12, Table 4.14, Table 4.16, Table 4.18, Table 4.20 in Section 4.3, Table 5.6, Table 5.8, Table 5.10, Table 5.12, Table 5.14, Table 5.16 in Section 5.3, and Table 6.6 in Section 6.3.
Load allocations for pollutants from nonpoint sources (NPS):	Pathogen Indicator, *E. coli*. The load allocations (LA) for point sources for each segment are listed in Table 4.6, Table 4.8, Table 4.10, Table 4.12, Table 4.14, Table 4.16, Table 4.18, Table 4.20 in Section 4.3, Table 5.6, Table 5.8, Table 5.10, Table 5.12, Table 5.14, Table 5.16 in Section 5.3, and Table 6.6 in Section 6.3.
Margin of safety (MOS):	Pathogen Indicator, *E. coli*. An explicit MOS of 10% is utilized in the TMDL for all impaired reaches. Additionally, targeting the GM in each flow condition, rather than only the overall GM, provides an implicit MOS by requiring WQS compliance across flow conditions.

Consideration of seasonal variation:	Pathogen Indicator, *E. coli*. These TMDLs were developed based on the Iowa WQS primary contact recreation season that runs from March 15 to November 15. Allocations are developed for a range of flow conditions, which help account for wet and dry periods within the recreation season.
Reasonable assurance that load and wasteload allocations will be met:	For nonpoint sources, reasonable assurance is provided by: (1) planned implementation activities that address the pollutant of concern, (2) local stakeholders working towards implementation of appropriate BMPs, (3) detailed requirements for watershed planning to ensure that 319 applications meet EPA requirements, and (4) available monetary support for nonpoint source pollution reduction. See Section 3.4 for more detailed discussion of reasonable assurance. For point sources, reasonable assurance is provided through NPDES permits.
Allowance for reasonably foreseeable increases in pollutant loads:	Because there are several unsewered communities in the watershed a reserve wasteload allocation was calculated in case they upgrade to a wastewater treatment system in the future.
Implementation plan:	A general implementation plan is outlined in Section 7 to guide local citizens, government, and water quality groups in the development of more detailed plans for individual streams within the Upper Chariton River Watershed. E. coli reduction will be accomplished through a combination of land use, livestock / manure, stormwater, and wastewater management strategies.

1. Introduction

The Federal Clean Water Act requires states to assess their waterbodies every even numbered year and incorporate these assessments into the 305(b) Water Quality Assessment Report. Assessed lakes and streams that do not meet Iowa Water Quality Standards (WQS) criteria are placed on the 303(d) Impaired Waters List. Subsequently, a Total Maximum Daily Load (TMDL) for each pollutant must be calculated and a Water Quality Improvement Plan written for each impaired water body.

A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can tolerate without exceeding WQS and impairing the waterbody's designated uses. The TMDL calculation is represented by the following general equation:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

Where:	TMDL	= total maximum daily load
	LC	= loading capacity
	∑WLA	= sum of wasteload allocations (point sources)
	∑LA	= sum of load allocations (nonpoint sources)
	MOS	= margin of safety (to account for uncertainty)

Fifteen segments in the Upper Chariton River Watershed, located in Clark, Lucas, Monroe, Decatur, Wayne, and Appanoose Counties in southern Iowa, are on the impaired waters list due to levels of indicator bacteria (*E. coli*) that violate state water quality criteria. The impaired segments include six main stem segments and nine tributaries (Figure 1.1 and Table 1.1).

One purpose of this Water Quality Improvement Plan (WQIP) for the Upper Chariton River watershed is to provide a TMDL for indicator bacteria. The second purpose of the plan is to provide local stakeholders and watershed managers with a tool to promote awareness of water quality issues, develop a watershed management plan, and implement water quality improvement projects. This WQIP includes an assessment of the existing *E. coli* loads to each impaired segment, as well as a determination of how much *E. coli* each segment can tolerate and without exceeding standards.

The plan includes a description of potential actions that can reduce pollution to the streams. These actions are sometimes referred to as best management practices (BMPs) aimed to improve water quality in the Upper Chariton River Watershed, with the ultimate goal of meeting water quality standards. These BMPs are outlined in Section 7 Implementation Plan.

The Iowa Department of Natural Resources (Iowa DNR) recommends a phased approach to watershed management. A phased approach is helpful when the origin, interaction, and quantification of pollutants contributing to water quality problems are complex and difficult to fully understand and predict. Iterative implementation of improvement practices and additional water quality assessment (i.e., monitoring) will help ensure progress towards water quality standards, maximize cost efficiency, and prevent unnecessary or ineffective implementation of costly BMPs. A water quality monitoring plan designed to help assess water quality improvement and BMP effectiveness is provided in Section 8.

This plan will be of little value unless additional watershed improvement activities and BMPs are implemented. This will require the active engagement of local stakeholders and the collaboration of several state and local agencies. Experience has shown that locally-led watershed plans have the highest potential for success. The Watershed Improvement Section of Iowa DNR has designed this plan for stakeholder use and may be able to provide technical support for the improvement of water quality in the Upper Chariton River Watershed.

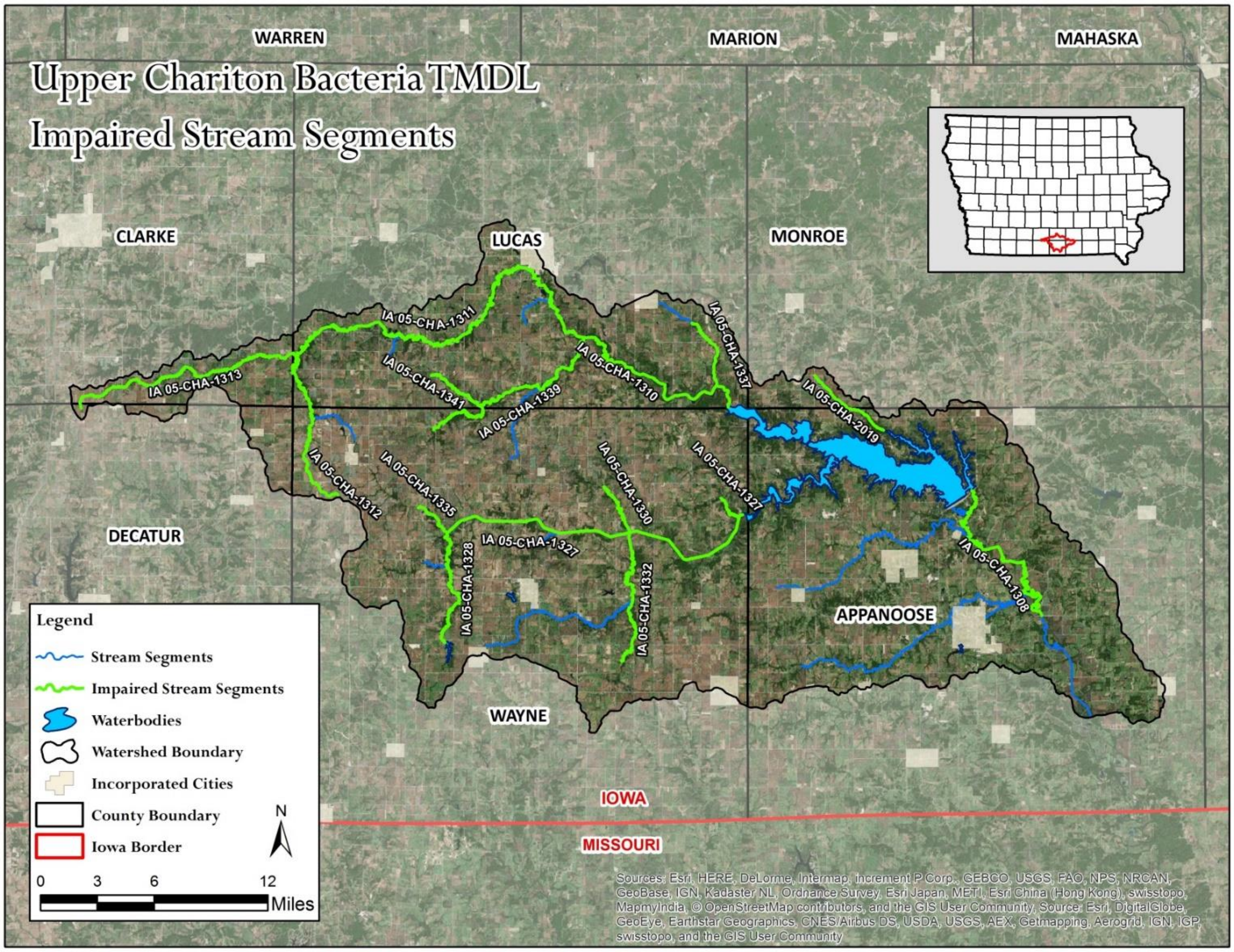

Figure 1.1. Impaired segments of the Upper Chariton River Watershed

Table 1.1. Impaired Segments in the Upper Chariton River Watershed.

Segment name	Segment ID	HUC 10
Chariton River	IA 05-CHA-1308	Cooper Creek –Chariton River
Chariton River	IA 05-CHA-1310	Wolf Creek – Chariton River
Chariton River	IA 05-CHA-1311	Wolf Creek – Chariton River
Chariton River	IA 05-CHA-1312	Wolf Creek – Chariton River
Chariton Creek	IA 05-CHA-1313	Wolf Creek – Chariton River
South Fork Chariton River	IA 05-CHA-1327	South Fork Chariton River
South Fork Chariton River	IA 05-CHA-1328	South Fork Chariton River
Walker Branch	IA 05-CHA-1329	South Fork Chariton River
Jordan Creek	IA 05-CHA-1330	South Fork Chariton River
Jackson Creek	IA 05-CHA-1332	South Fork Chariton River
Ninemile Creek	IA 05-CHA-1335	South Fork Chariton River
Honey Creek	IA 05-CHA-1337	Wolf Creek – Chariton River
Wolf Creek	IA 05-CHA-1339	Wolf Creek – Chariton River
Fivemile Creek	IA 05-CHA-1341	Wolf Creek – Chariton River
Honey Creek	IA 05-CHA-2019	Wolf Creek – Chariton River

2. Description and History of the Upper Chariton River

2.1 History and Land Use

The impaired segments are located above the Rathbun Lake dam, with the exception of the bottom-most segment of the Chariton River, which is immediately downstream of the dam. Rathbun Lake is the primary water source for the Rathbun Regional Water Association, which provides about 8 million gallons of water per day to almost 80,000 people for residential, agricultural, and industrial use. The dam was constructed in the late 1960s and is maintained by the US Army Corps of Engineers. The lake's watershed covers 354,000 acres, more than half of which is used for agriculture. Corn and soybean row crops account for 146,000 acres, while grassland comprises another 83,500 acres. It is estimated that cropland has increased in the watershed by 38,700 acres in the last decade, mainly due to conversion of grassland and land once enrolled in the Conservation Reserve Program.

The Upper Chariton River Watershed is located within the Loess Flats and Till Plains—Central Irregular Plains ecoregion (40a) (Prior 1991; Griffith et al., 1994). The landscape is characterized by rolling uplands, integrated drainage, and occasional broad alluvial plains. Most soils in the watershed formed in loess, glacial till, or alluvium. The majority of soils in the watershed have characteristics that limit their potential uses, such as high susceptibility to erosion, high water retention, and low fertility.

Land uses within the watershed are dominated by agriculture (Table 2.1 and Figure 2.1). There are eight wastewater treatment facilities within this watershed.

Table 2.1. Land uses in the Rathbun Lake watershed.

General Land Use	Land Use Description	Area	
		Acres	Percent
Grassland	Both pasture and ungrazed grassland	133,581.0	37.7
Row Crops w/ Conventional Rotations	Corn-soybean, soybean-corn, and continuous corn	98,490.5	27.8
Row Crops w/ Extended Rotations	Includes areas with multiple years of non-row crop (e.g., alfalfa)	32,363.8	9.2
Forest/Timber	All forested areas	48,969.7	13.8
Water/ Wetlands	Ponds, lakes, and wetlands	16,573.1	4.7
Urban/Developed	Includes all developed areas	14,706.1	4.2
Alfalfa/Hay	Alfalfa and hay not in extended rotations	9,351.2	2.6
Total		354,035.4	100

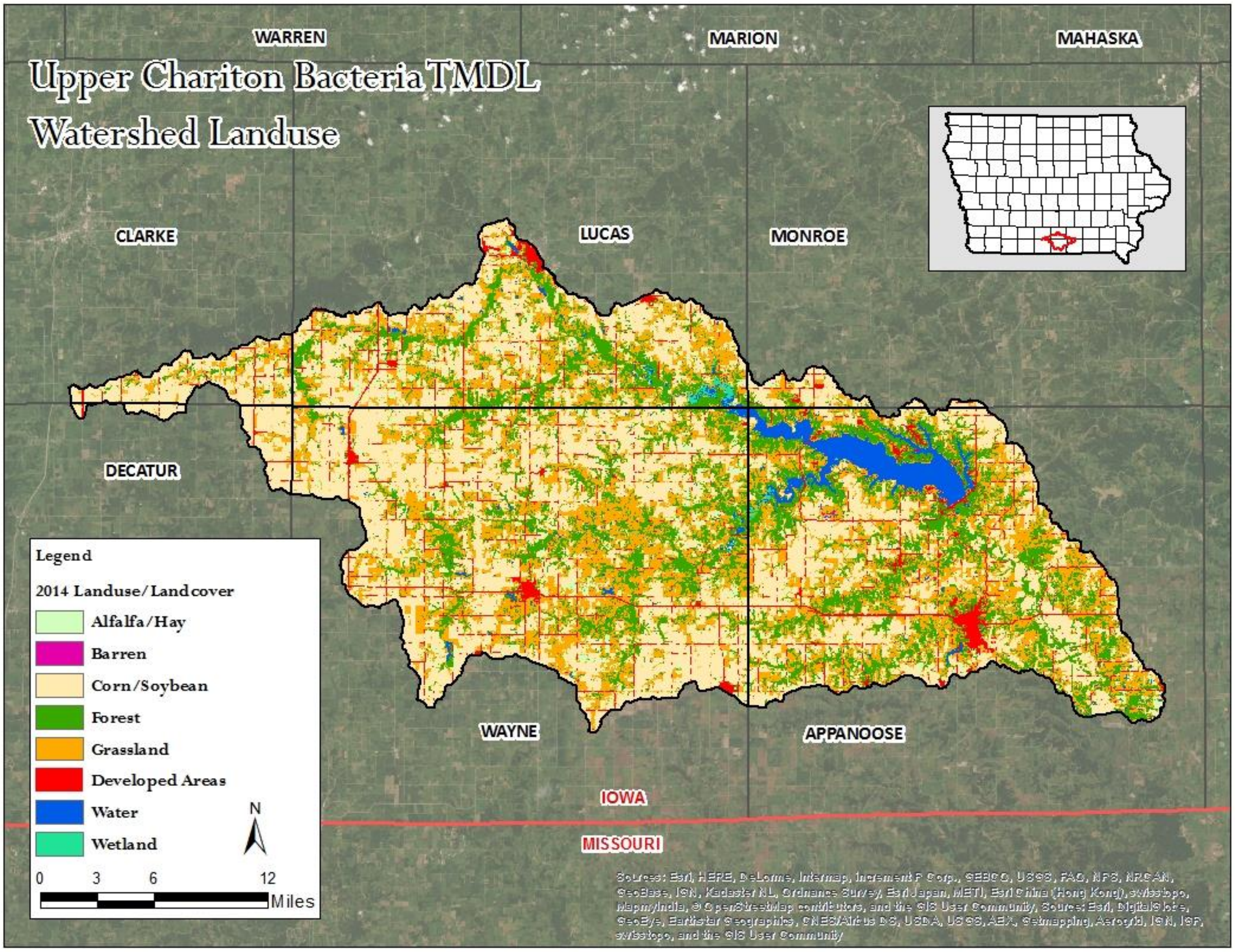

Figure 2.1. Upper Chariton River Watershed Landuse.

2.2 Hydrology, Soils, Climate, and Topography

Nine soils series make up over 77 percent of the Upper Chariton River Watershed. These soils are largely glacial till underlying loess deposits on the surface. Soils with high clay content and low permeability dominate the landscape, making the watershed particularly susceptible to high runoff rates and soil erosion, especially on steep slopes. The topography consists of rolling hills interspersed with level, upland divides and alluvial lowlands. The drainage pattern is dendritic, with the upland plains and highly dissected stream valleys. As a result, there are many hillslopes, and over 50 percent of the watershed has a slope exceeding 5 percent. The flattest slopes are found in the alluvial floodplains and a few upland ridgelines between drainage divides.

There are 6 weather stations within 8 miles of the Upper Chariton River Watershed where temperature and precipitation are measured and recorded. These include National Weather Service (NWS) Cooperative Program (COOP) stations in Allerton, Chariton, and Osceola (IEM, 2015). Additionally, temperature and precipitation data were obtained from National Climatic Data Center (NCDC) stations at Leon, Promise City, and at the Rathbun Lake Dam (NOAA, 2015).

Based on the Rathbun Lake Dam weather station, average annual precipitation near Rathbun Lake was 40.2 inches from 1995-2014 (Figure 2.2). The climate of south-central Iowa is relatively humid, with precipitation exceeding evapotranspiration (ET) nearly year-round, with some exceptions in late summer months (Figure 2.3). However, in very dry years such as 2012, ET can exceed precipitation. Precipitation in the Rathbun lake area varies not only from year-to-year, but also seasonally. Over 71 percent of the annual precipitation falls from April to September (i.e., during the growing season). The past 8 years have been wetter than normal, with an average annual rainfall of 47.4 inches. Years 2007, 2008, and 2010 were extreme years with several flooding events and annual rainfall totals more than 25 percent above normal each year. Rainfall events resulting in runoff can carry bacteria off the landscape to streams, elevating bacteria levels above water quality standards.

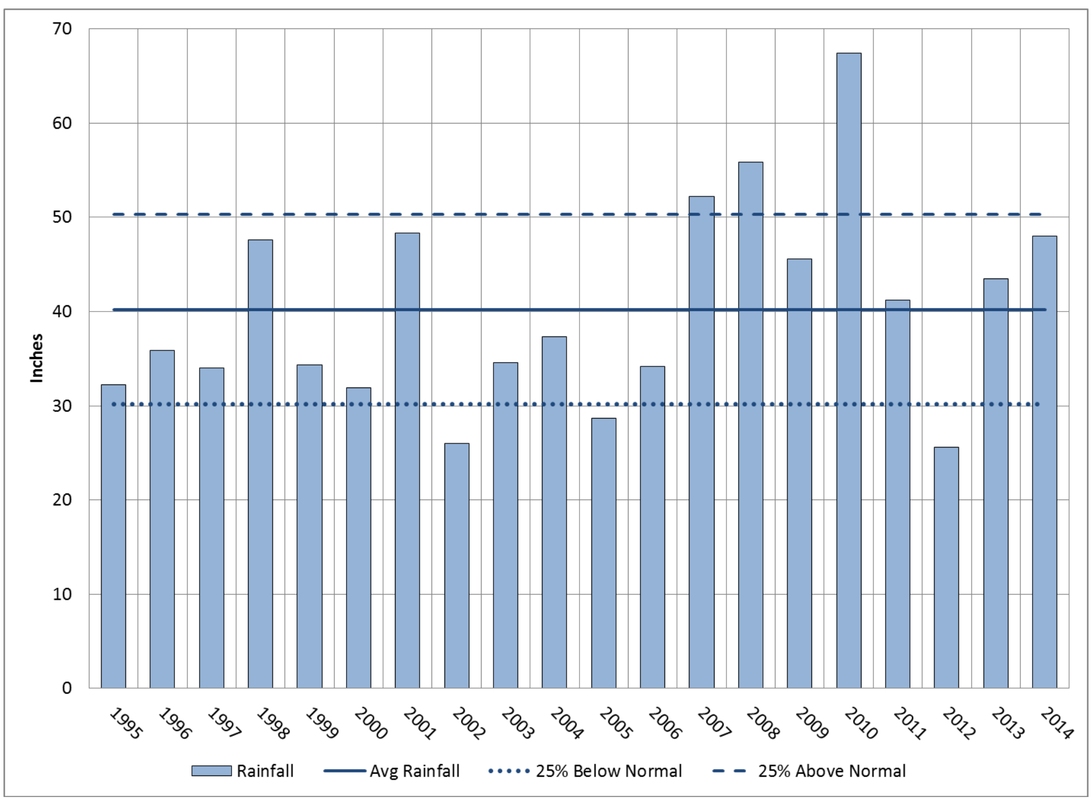

Figure 2.2. Annual rainfall totals at the Rathbun Lake Dam from 1995-2014

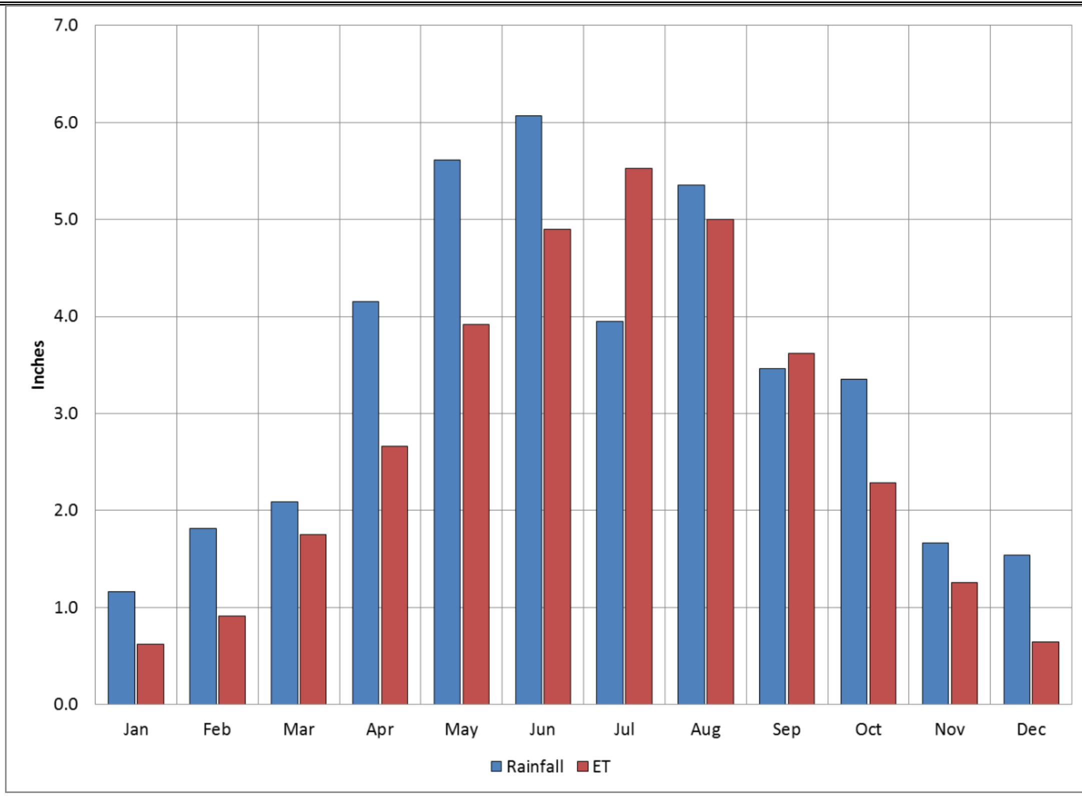

Figure 2.3. Monthly precipitation and estimated evapotranspiration for the Upper Chariton River Watershed

3. General Stream and Environmental Information

3.1 Problem Identification

15 stream segments in the Upper Chariton River Watershed do not meet water quality standards (WQS) and are not fully supporting Class A1 (primary contact recreation) uses due to the presence of high levels of an indicator bacteria called *Escherichia coli* (*E. coli*). High *E. coli* levels in a waterbody can indicate the presence of potentially harmful bacteria and viruses (also called pathogens). Under Iowa Administrative Code (567 Iowa Administrative Code, Chapter 61, (IAC)), streams are impaired for *E. coli* if the geometric mean (GM) of all samples exceeds 126 orgs/100 mL of water. This standard is only applicable during the recreation season, defined as March 15 through November 15. The following sections will apply to all TMDL sections in this document.

General Description of the Pollutants

Fecal material from warm-blooded animals contains many microorganisms. Some of these microorganisms can cause illness or disease if ingested by humans. The term pathogen refers to a disease-causing microorganism, and can include bacteria, viruses, and other microscopic organisms. Humans can become ill if they come into contact with and/or ingest water that contains pathogens.

It is not practical to test water for every possible pathogen that may be present - there are simply too many different kinds of pathogens. Instead, water quality assessments typically test for an organism such as total coliform, fecal coliform, or *E. coli* to indicate the presence of pathogens from fecal material. *E. coli* is a type of fecal coliform, and its presence theoretically correlates with illnesses that result from human exposure to water that is contaminated with fecal material (Mishra et al, 2008). It should be noted that not all types of *E. coli* cause human illness; however, the presence of *E. coli* indicates the likelihood that pathogens are present. For the purposes of this TMDL, *E. coli* is used as the indicator bacteria. The two primary reasons for using *E. coli* are: (1) the EPA currently considers *E. coli* to be the preferred bacterial indicator, and (2) Iowa's WQS are written for *E. coli*.

Problem Statement

Water quality assessments indicate that primary contact recreation is either "not supported" or only "partially supported" in these segments due to high levels of indicator bacteria (*E. coli*) that violate the state's WQS. The significance of the impairments noted in the assessments is that desirable recreational activities, such as swimming and wading, are not supported by existing water quality in the impaired segments. As a result of these findings, the Federal Clean Water Act requires that TDMLs for *E. coli* be developed for all the impaired segments.

Stream Segment Designations and Descriptions

In February 2008, changes to Iowa's surface water classifications were approved by the EPA and all segments were presumed to be Class A1, primary contact recreation until a use attainability assessment could be completed and approved by the EPA. Stream designations are defined and classified for protection of beneficial uses in the Iowa Administrative Code (IAC) 567-61.3(1).

Beneficial uses as defined in the IAC 567-61.3(1) are cited below.

- 567-61.3(1)(b)(1) Primary contact recreational use (Class "A1"). Water in which recreational or other uses may result in prolonged and direct contact with the water, involving considerable risk of ingesting water in quantities sufficient to pose a health hazard. Such activities would include, but not be limited to, swimming, diving, water skiing, and water contact recreation canoeing.
- 567-61.3(1)(b)(6) Warm water-Type 1 (Class "B(WW-1)"). Waters in which temperature, flow and other habitat characteristics are suitable to maintain warm water game fish populations along with a resident aquatic community that includes a variety of native nongame fish and invertebrate species. These waters generally include border rivers, large interior rivers, and the lower segments of medium-size tributary streams.
- 567-61.3(1)(b)(7) Warm water-Type 1 (Class "B(WW-2)"). Waters in which flow or other habitat characteristics are capable of supporting a resident aquatic community that includes a variety of native nongame fish and invertebrate species. The flow and other physical characteristics limit the maintenance of warm water game fish populations. These waters generally consist of small perennially flowing streams.

- 567-61.3(1)(b)(10). Human health (Class "HH"). Waters in which fish are routinely harvested for human consumption or waters both designated as a drinking water supply and in which fish are routinely harvested for human consumption.

Stream segment designations and descriptions for individual impaired stream segments will be discussed in the respective sections of this report.

Data Sources and Monitoring Sites

The primary sources of water quality data used in the development of this WQIP are water quality data collected by the Iowa DNR and the USGS National Water-Quality Assessment (NAWQA) Program. These data consist primarily of grab samples collected by the agencies between 1997 and 2012. When available, additional water quality data through 2016 was utilized. Each section will outline specific sources used, but the following list summarizes sources of additional data used for this WQIP:

- Streamflow data collected by the USGS at multiple surface water gaging stations
- Precipitation data from the National Weather Service Cooperative Observer Program (NWS COOP) (IEM, 2015)
- 10-m Digital Elevation Model (DEM) available from DNR GIS library
- SSURGO soils data maintained by United States Department of Agriculture -Natural Resource Conservation Service (USDA-NRCS)
- U.S. Department of Agriculture National Agricultural Statistics Service Cropland Data Layer (USDA CDL) reflecting 2014 conditions
- Aerial images (various years) collected and maintained by DNR
- Water Quality data collected by the USDA's Agricultural Research Service National Laboratory for Agriculture and the Environment (NLAE)

3.2 TMDL Target

Selection of Environmental Conditions

The critical period for the impairment occurs in the recreational season of March 15 to November 15.

Pollutant Loading Capacity

Attainment of the WQS to fully support primary contact recreation requires that the GM for *E. coli* concentrations be no greater than 126 orgs/100 mL and the single sample maximum (SSM) be not greater than 235 orgs/100 mL (Iowa Administrative Code 567, Chapter 61, Water Quality Standards for Class A1 uses). The methods used to develop the *E. coli* TMDLs for the Upper Chariton River Watershed are based on the assumption that compliance with the SSM will coincide with attainment of the GM targets set forth in this TMDL. Therefore, the loading capacity of each TMDL segment is the maximum number of *E. coli* organisms that can be in the stream while meeting the GM criterion of 126 orgs/100 mL.

Decision Criteria for WQS Attainment

Load duration curves (LDCs) constructed using mean daily flows and the GM criterion were used to quantify the loading capacity of each impaired segment, in terms of load (orgs/day), across a range of flow conditions. Points above the red GM curve in Figure 3.1 represent violations of the WQS, whereas points below the curves comply with WQS.

WQS will be attained in the impaired stream segments when the monitored *E. coli* concentration meets the GM criterion of 126 orgs/100 mL during the recreational season of March 15 - November 15.

3.3 Pollution Source Assessment

Existing Loads

E. coli loads were estimated by multiplying observed concentrations (orgs/100 mL) by the mean daily flow (cfs) on the day the sample was collected (including a unit's conversion). Using the load duration curve (LDC) approach, these measured loads are plotted against the flow duration interval, which allows loads to be grouped into the same flow conditions loading capacity. Figure 3.1 is a load duration curve for the Chariton River segment IA 05-CHA-1312 and is presented here as an example of the format of the LDC used throughout this WQIP and illustrates both observed loads and the flow-variable loading capacity, which is based on the WQS of 126 orgs/100 mL for the GM concentration.

Each diamond in Figure 3.1 represents an observed *E. coli* concentration and flow, and hence corresponding load. Green-shaded diamonds (◆) indicate samples that were collected in early spring (March to May), orange shading (◆) represents samples collected in the summer (June to September), and gray shading (◆) indicates samples that were collected in the late fall (October to November).

LDCs for each stream segment show the observed GM loading (green, dotted lines) for each flow condition and the target GM loading (red, dashed line). The difference between these two is the departure from the loading capacity.

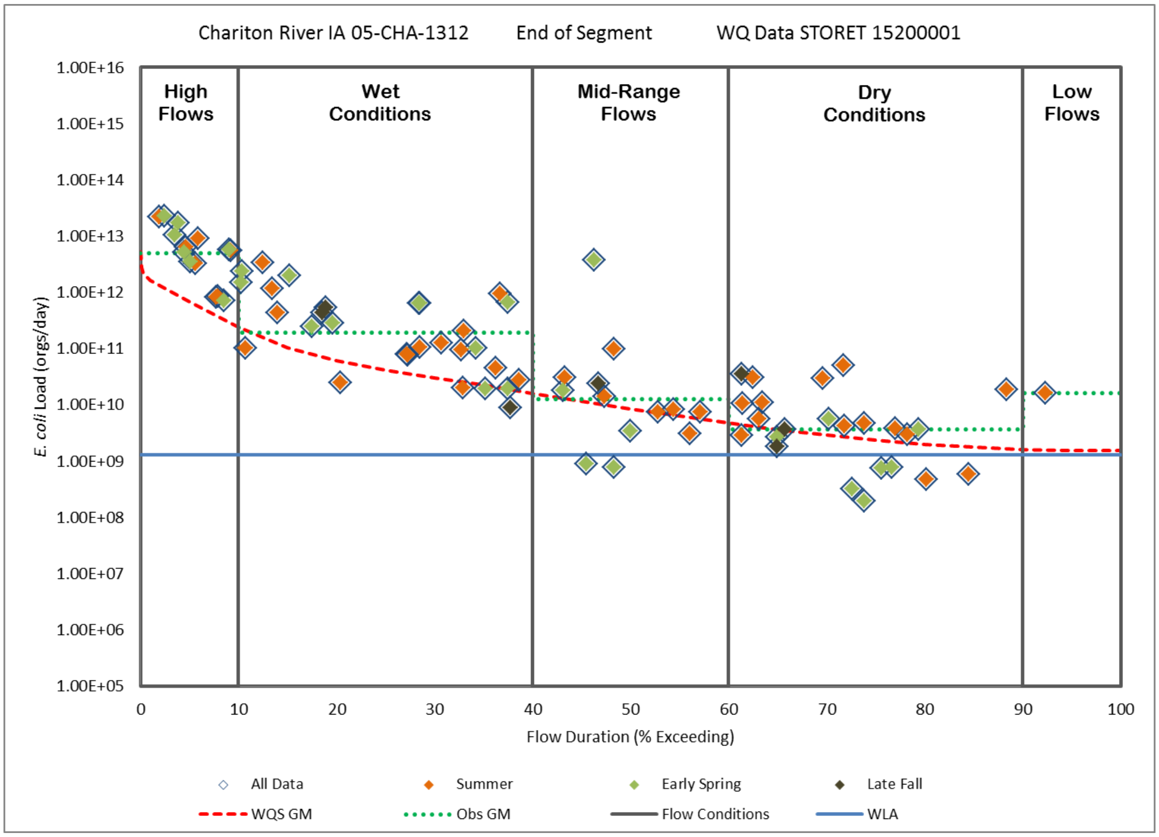

Figure 3.1. Example Load Duration Curve for Chariton River Segment IA 05-CHA-1312

Potential Sources

Figure 3.2 shows some potential *E. coli* contributing sources by flow condition. Each box represents a potential source and overlaps the flow conditions in which it is most likely to contribute to the impairment. The boxes are color coded with red shading indicating the condition in which the source has a greater impact to water quality and green shading indicates the condition in which the source has a lower impact to water quality.

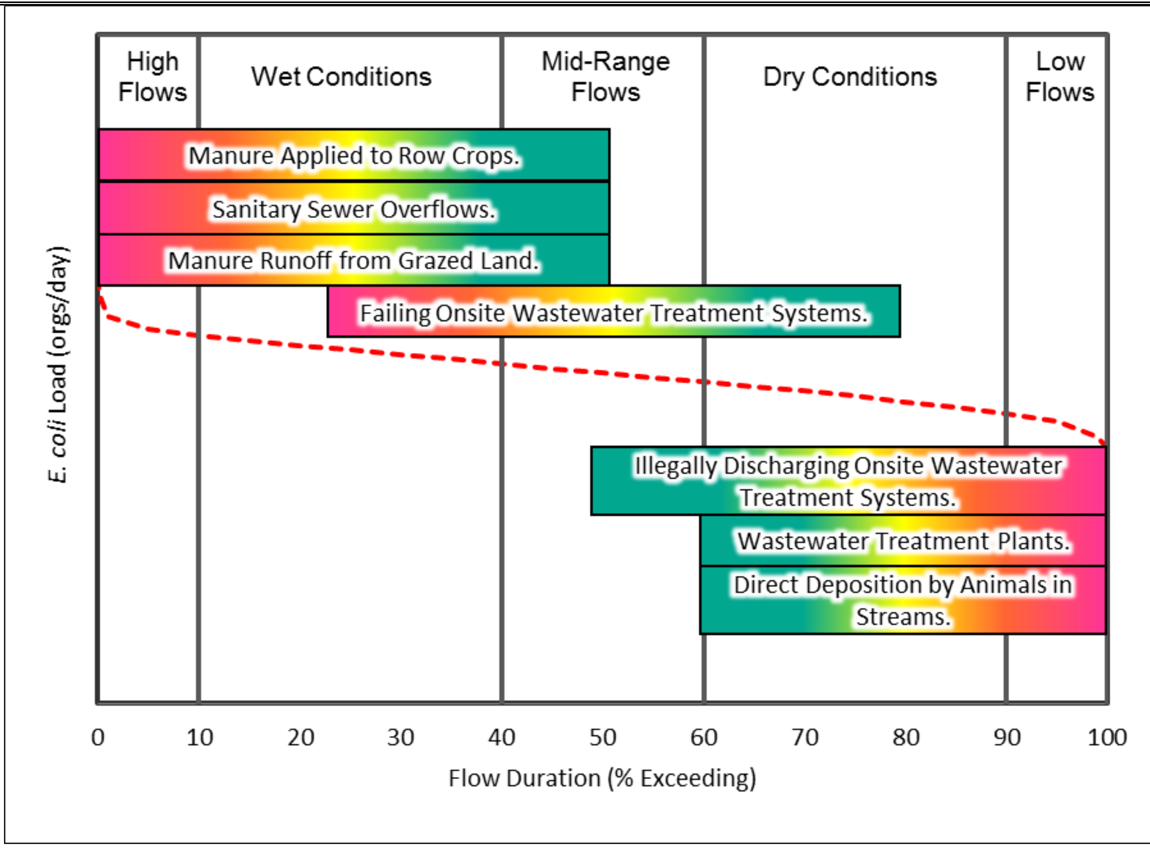

Figure 3.2. Potential *E. coli* Sources by Flow Condition.

3.4 Reasonable Assurance

Under current EPA guidance, TMDLs that allocate loads to both point sources (WLAs) and nonpoint sources (LAs) must demonstrate reasonable assurance that required load reductions will be implemented. For point sources, reasonable assurance is provided through NPDES permits. Permits include operation requirements and compliance schedules that are developed based on water quality protection. For nonpoint sources, allocations and proposed implementation activities must satisfy four criteria:

- They must apply to the pollutant of concern
- They will be implemented expeditiously
- They will be accomplished through effective programs
- They will be supported by adequate water quality funding

Nonpoint source measures developed in the Upper Chariton River Watershed TMDL satisfy all four criteria. First, LAs and implementation activities described in Section 7 of the report apply directly to *E. coli*. Attainment of designated uses and existing water quality are measured using these indicator bacteria. Second, there are several active watershed groups already pursuing detailed watershed planning and implementation activities in the Upper Chariton River Watershed. Third, Iowa DNR has set forth detailed requirements for watershed planning and implementation to ensure that watershed management plans and Section 319 applications meet EPA requirements and include: approximate timelines for implementation activities, ongoing monitoring to track progress towards water quality improvement, a phased and prioritized schedule of activities, and target the impairment appropriately. Finally, ongoing monetary support is available for implementation in a variety of forms, including Section 319 grants, as well as other federal, state, and local resources.

4. Total Maximum Daily Load (TMDL) for Wolf Creek-Chariton River for Indicator Bacteria (*E. coli*)

Total Maximum Daily Loads (TMDLs) are required for the eight impaired waterbody segments in the Wolf Creek-Chariton River HUC 10 (1028020102) by the Federal Clean Water Act. This section of the Water Quality Improvement Plan (WQIP) describes the pollutant, in this case Escherichia coli (*E. coli*), leading to the impairments and the maximum amount of *E. coli* the stream segments can assimilate and still support their designated uses.

4.1 Problem Identification

The primary contact recreation (Class A1) uses in Chariton Creek, three segments of the Chariton River, Fivemile Creek, Wolf Creek, and two different Honey Creek segments are not supported due to the presence of high levels of indicator bacteria (*E. coli*) (Figure 4.1). High *E. coli* levels in a waterbody can indicate the presence of potentially harmful bacteria and viruses (also called pathogens). Humans can become ill if they come into contact with and/or ingest water that contains pathogens. Under Iowa Administrative Code, streams are impaired for *E. coli* if they exceed a single sample maximum of 235 colony forming units (cfu) per 100 mL of water or the geometric mean of all samples exceeds 126 cfu/100 mL of water. This standard is only applicable during the recreation season, defined as March 15 through November 15.

Both point and nonpoint sources of pollution can be responsible for high *E. coli* levels. Permitted sources include municipal wastewater treatment facilities (WWTF) and discharging onsite wastewater treatment and disposal systems. Onsite wastewater treatment systems are often called septic systems, even though not all systems include a septic tank. Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the stream. Specific examples of potential nonpoint sources of bacteria include cattle with direct access to streams, manure applied to row crops, non-permitted onsite wastewater systems, and natural sources such as wildlife.

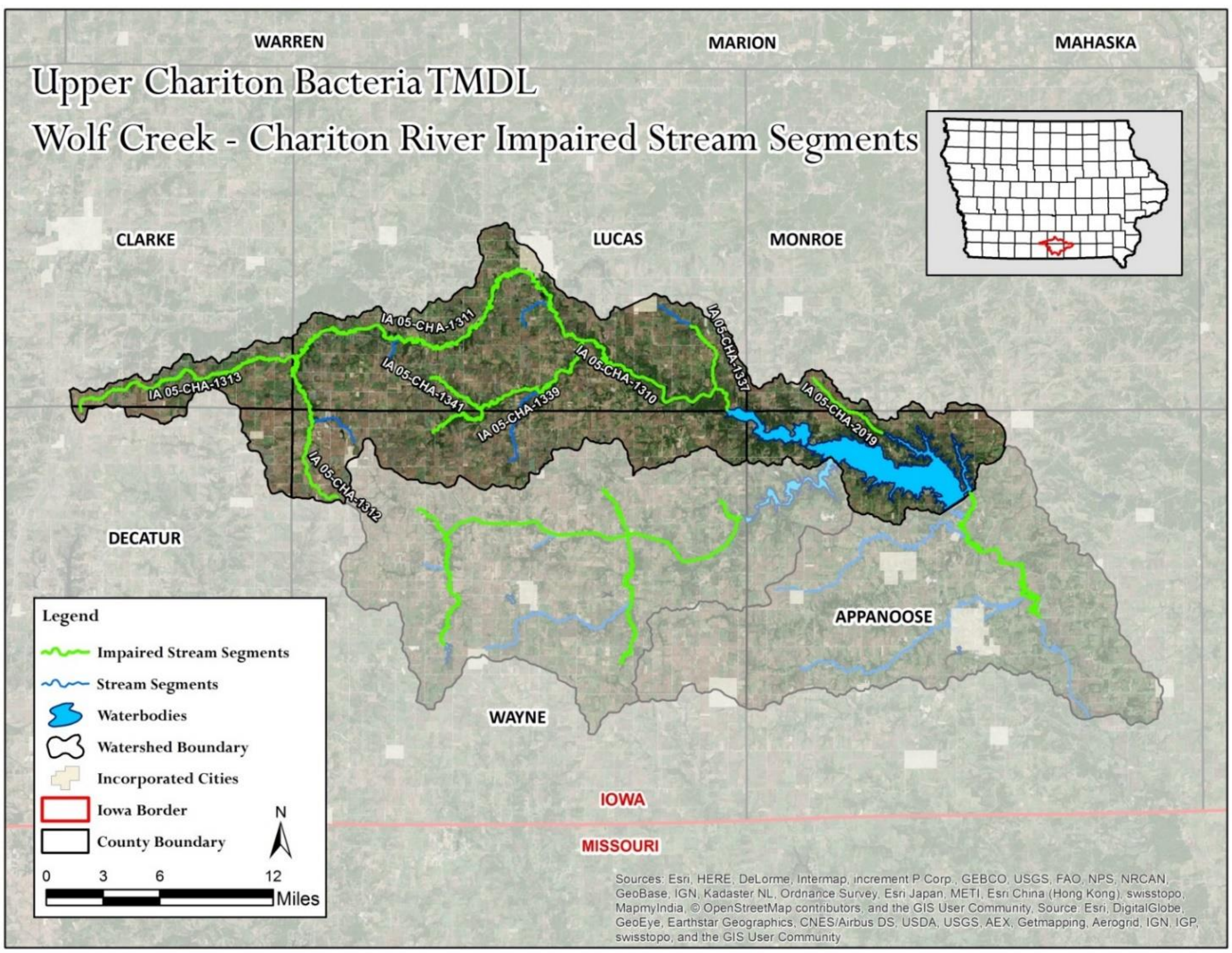

Figure 4.1. Map of the Wolf Creek - Chariton River HUC 10 with impaired stream segments

Stream Segment Designations and Descriptions
Eight stream segments within the Wolf Creek-Chariton River HUC 10 do not meet water quality standards (WQS) and are not fully supporting class A1 (primary contact) designated uses due to presence of high levels of indicator bacteria called Escherichia coli (*E. coli*). Prior to 2008, none of the listed segments were designated for primary contact recreation (Class A1). In February 2008, changes to Iowa's surface water classifications were approved by the EPA and all segments were presumed to be Class A1, primary contact recreation. Table 4.1 is a summary of the impaired stream segments, segment identification, location description, segment length, and designated uses.

Table 4.1. Impaired stream segments and designated uses.

Stream name	Segment ID	Location Description	Stream length	Designated Uses
Chariton River	IA 05-CHA-1310	from upper end of Rathbun Lake to Hwy 14, Lucas Co.	18.8 mi	A1 B (WW2)
Chariton River	IA 05-CHA-1311	from Hwy 14 (Lucas Co.) to confluence with Chariton Cr. in S19, T71N, R23W, Lucas Co.	22.7 mi	A1 B (WW2)
Chariton River	IA 05-CHA-1312	from confluence with Chariton Creek (S19, T71N, R23W, Lucas Co.) to headwaters	10 mi	A1 B (WW1)
Chariton Creek	IA 05-CHA-1313	mouth (S19, T71N, R23W, Lucas Co.) to headwaters	14 mi	A1 B (WW1)
Honey Creek	IA 05-CHA-1337	mouth (S26, T71N, R20W, Lucas Co.) to confluence with unnamed tributary in S10 ,T71N, R20W, Lucas Co.	4.2 mi	A1 B (WW2)
Wolf Creek	IA 05-CHA-1339	mouth (S15, T71N, R21W, Lucas Co.) to confluence with unnamed tributary in E 1/2, NW 1/4, S8, T70N, R22W, Wayne Co.	14.6 mi	A1 B (WW2)
Fivemile Creek	IA 05-CHA-1341	mouth (S35, T71N, R22W, Lucas Co.) to confluence with unnamed tributary in S29, T71N, R22W, Lucas Co.	3.5 mi	A1 B (WW2)
Honey Creek	IA 05-CHA-2019	from upper end of Honey Creek arm of Rathbun Lake (NW 1/4, S8, T70N, R18W, Appanoose Co.) to headwaters in NW 1/4, S27, T71N, R19W, Monroe Co.	5.4 mi	A1 B (WW1)

Problem Statement
Water quality assessments indicate that primary contact recreation is "not supported" in these segments due to high levels of indicator bacteria (*E. coli*) that routinely violate the state's water quality standards (Table 4.2). The significance of the impairments noted in the assessments is that desirable recreational activities, such as swimming and wading, are not adequately provided by existing water quality in the impaired segments. As a result of these findings, the Federal Clean Water Act requires that TDMLs be developed for all the impaired segments for *E. coli*.

Table 4.2. Impairment criteria for each impaired segment.

Stream name	Segment ID	Geometric mean (impairment at 126 cfu/100mL)			Single Sample Max. (235 cfu/100 mL)
		2010	2011	2012	% samples exceeding
Chariton River	IA 05-CHA-1310	757	208	1,425	74%
Chariton River	IA 05-CHA-1311	757	208	1,425	74%
Chariton River	IA 05-CHA-1312	587	371	370	75%
Chariton Creek	IA 05-CHA-1313	665	186	314	67%
Honey Creek	IA 05-CHA-1337	533	607	1,692	73%
Wolf Creek	IA 05-CHA-1339	959	185	2,469	79%
Fivemile Creek	IA 05-CHA-1341	1,240	162	137	80%
Honey Creek	IA 05-CHA-2019	509	578	3,868	79%

Data Sources

Sources of data used in the development of this TMDL include those used in the 2016 305(b) report, several sources of additional flow and water quality data, and non-water quality related data used for model development. Monitoring sites are listed in Table 4.3. Specific data includes:

- Stream data collected by Iowa DNR Watershed Improvement Section staff for the purpose of TMDL development
- Stream data collected by U.S. Army Corps of Engineers (USACE), Kansas City District, as part of its reservoir monitoring program
- Streamflow data collected by the U.S. Geological Survey (USGS) at multiple surface water gaging stations (USGS, 2015)
- Precipitation and temperature data from the National Weather Service Cooperative Observer Program (NWS COOP) (IEM, 2015)
- Precipitation and temperature data from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) (NOAA, 2015)
- 10-m Digital Elevation Model (DEM) available from DNR GIS library
- SSURGO soils data maintained by United States Department of Agriculture -Natural Resource Conservation Service (USDA-NRCS)
- U.S. Department of Agriculture National Agricultural Statistics Service Cropland Data Layer (CDL) reflecting 2006 conditions (USDA-NASS, 2013)
- Aerial images (various years) collected and maintained by DNR

Table 4.3. WQ Monitoring Sites of Wolf Creek - Chariton River HUC 10.

Site Name	ID	Longitude	Latitude
Brush Creek at 420th St (RA-32)	STORET 15200001	-93.5568	40.9274
Chariton River (RA-33)	STORET 15200002	-93.5614	40.9378
Chariton River at Hwy 14 (RA-15)	STORET 15590001	-93.3081	40.9922
Honey Creek at 430th Lane (RA-40)	STORET 15590002	-93.1282	40.9416
Wolf Creek at CR H50 (RA-41)	STORET 15590003	-93.2685	40.9413
Fivemile Creek at CR S23 (RA-42)	STORET 15590004	-93.3846	40.9082
Honey Creek at 550th (RA-43)	STORET 15680001	-93.0025	40.9020
Wolf Creek at CR S23 (RA-44)	STORET 15930007	-93.3844	10.8963

Interpreting the Data

Analysis of the data show consistently high *E. coli* levels that exceed the criterion set in Iowa's WQS for primary contact recreation. Significant reductions in *E. coli* loading will be required to comply with the standards and fully support the designated recreational use in the impaired segments.

Identification of pollutant sources

There are a variety of *E. coli* sources in the Wolf Creek - Chariton River watershed. These sources can be divided into two categories, point and non-point sources. Point sources may include municipal separate storm sewer systems (MS4s), municipal and industrial wastewater treatment facilities (WWTFs), sanitary sewer overflows (SSOs), onsite wastewater systems with permitted discharges, and animal feeding operations (AFOs) regulated as concentrated animal feeding operations (CAFOs). Nonpoint sources include wildlife, manure application to row crops, grazing livestock and small feeding operations, direct deposition by livestock in streams, and non-permitted (i.e., non-discharging) onsite wastewater systems.

Load duration curves (LDCs) were used in the development of *E. coli* TMDLs for impaired stream segments in the Wolf Creek - Chariton River Watershed (Section 4.2). The use of LDCs is helpful for understanding the importance that hydrology plays on pollutant loading. Information illustrated in LDCs provides a basic understanding of the importance of potential pollutant sources, although the approach does not offer explicit calculation of source-specific pollutant loads. However, when analyzed in conjunction with a detailed inventory of sources, LDCs can provide a quantitative means of comparing the relative importance of specific pollutant sources.

Point Sources

There are a total of three active or pending NPDES permits for waste water treatment facilities (WWTF) in this watershed flowing into impaired segments. In addition, there are two unsewered communities (Le Roy, Weldon), seven general purpose permits, and seven confined animal feeding operations (CAFOs) of over 1,000 animal units requiring an NPDES permit. Figure 4.2 shows the locations of all NPDES permitted wastewater facilities, concentrated animal feeding operations, unsewered communities, and private facilities that discharge under an NPDES General Permit #4. A full inventory of dischargers and their respective WLAs is provided in Appendix C.

Nonpoint Sources

The nonpoint sources of pathogen indicators include contributors that do not have localized points of release into a stream. In the watershed these sources are:

- Grazing animals
- Direct deposition of manure in streams
- Land application and subsequent runoff of manure
- Developed / urban area runoff
- Wildlife
- Faulty septic tank systems

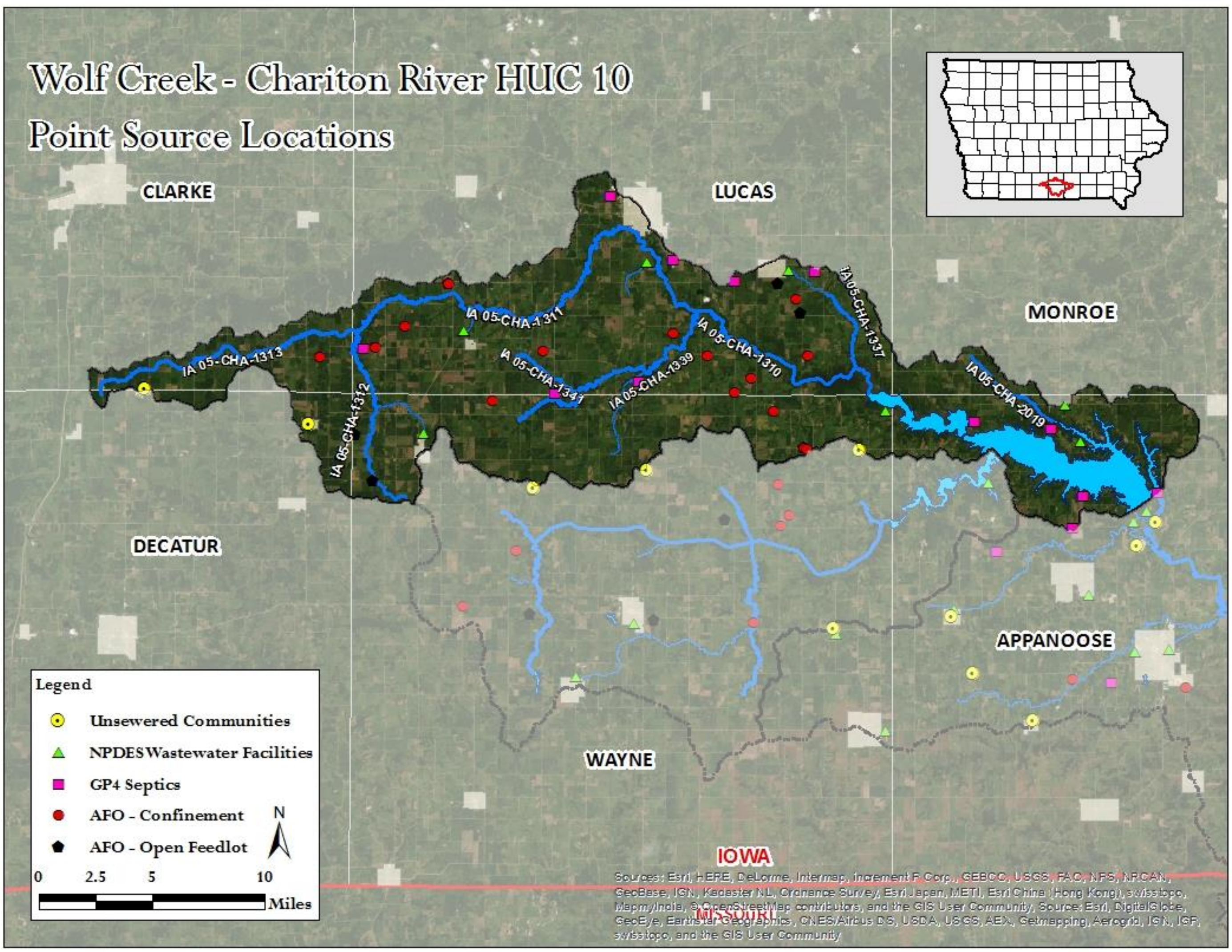

Figure 4.2. Map of the Wolf Creek - Chariton River point sources

4.2 Pollution Source Assessment

Departure from Load Capacity
The LDCs, observed loads, and observed GM loads for each flow condition are plotted in Figure 4.3 through Figure 4.10. This methodology enables calculation of a TMDL target at the midpoint of each flow condition for each impaired segment, as provided in even numbered tables from Table 4.6 through Table 4.20.

Allowance for increases in pollutant loads
There are two unsewered communities in the Wolf Creek-Chariton River HUC 10. A reserve wasteload allocation was calculated for each community and applied to the WLA for the associated segment. Appendix C.2 lists all the unsewered communities in the Upper Chariton watershed. Any new or expanded dischargers will be expected to meet the same end-of-pipe criteria (GM of 126 orgs/100 mL) as dischargers for which WLAs were calculated and included in this TMDL.

4.3 Pollutant Allocation

Wasteload allocation
A WLA was calculated for each wastewater treatment facility (WWTF), MS4 community, and an aggregate reserve WLA for unsewered communities in the watershed. Table 4.4 shows the aggregate WLA summary by facility type for the Wolf Creek - Upper Chariton River watershed. Individual WLAs for each discharger are included in Appendix C.

Table 4.4. Wasteload Allocations for Wolf Creek-Chariton River HUC-10.

Facility Type	Number of Facilities[1]	Flow (MGD)[2]	GM Conc (orgs/100 mL)	GM Load (orgs/day)
WWTF	3	0.715	126	3.40E+09
Unsewered	2	0.013	126	6.39E+07
CAFO[3]	7	--	126	0.00E+00
GP #4	7	--	126	--
Stormwater	0	--	126	0.00E+00
Totals	19	0.728	126	3.46E+09

[1]Facilities in HUC 10 watershed discharging into impaired segments
[2]Flows used to calculate the wasteload allocation. See Appendix C.
[3]Facilities with 1,000 or more AU requiring a NPDES permit

Load allocation
Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the stream. Specific examples of potential nonpoint sources of bacteria include animals directly depositing into streams, manure applied to row crops, manure runoff from grazed land, non-permitted onsite wastewater systems, and natural sources such as wildlife.

Margin of Safety
An explicit margin of safety (MOS) of 10 percent is applied to the calculation of loading capacities in this TMDL.

Load Duration Curve
Figure 4.3 through Figure 4.10 show load durations for the impaired stream segments in this watershed. Table 4.5 through Table 4.20 are the existing load estimates and the TMDL summary for each impaired segment.

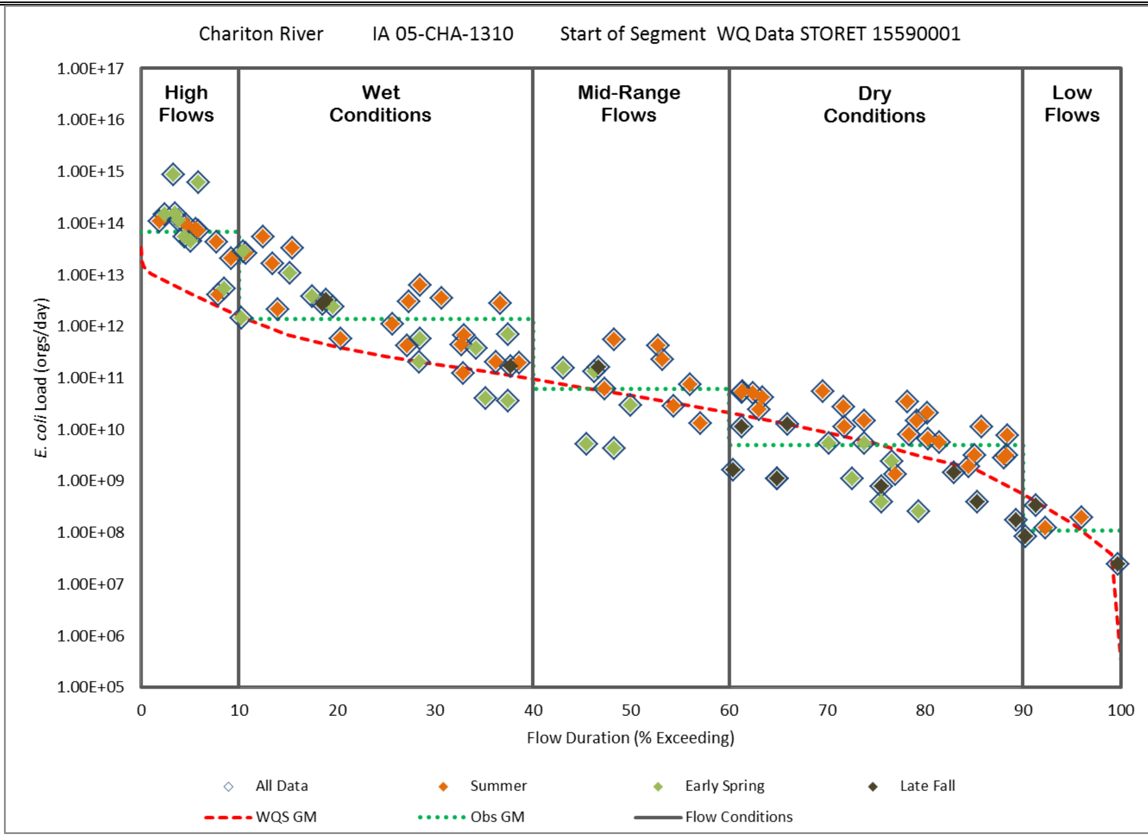

Figure 4.3. Load duration curve for IA 05-CHA-1310.

Table 4.5. Existing loads estimates for IA 05-CHA-1310

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	6.88E+13	1.39E+12	6.19E+10	5.06E+09	1.11E+08
GM Departure (% Reduction)	6.44E+13 (94)	1.13E+12 (81)	1.59E+10 (26)	-2.30E+08 (0)	-4.11E+07 (0)
Midpoint Flow (cfs)	1,425	85.9	14.9	1.7	0.05

Table 4.6. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1310

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	4.39E+12	2.65E+11	4.60E+10	5.29E+09	1.52E+08
WLA (orgs/day)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA (orgs/day)	3.95E+12	2.38E+11	4.14E+10	4.76E+09	1.37E+08
MOS (orgs/day)	4.39E+11	2.65E+10	4.60E+09	5.29E+08	1.52E+07

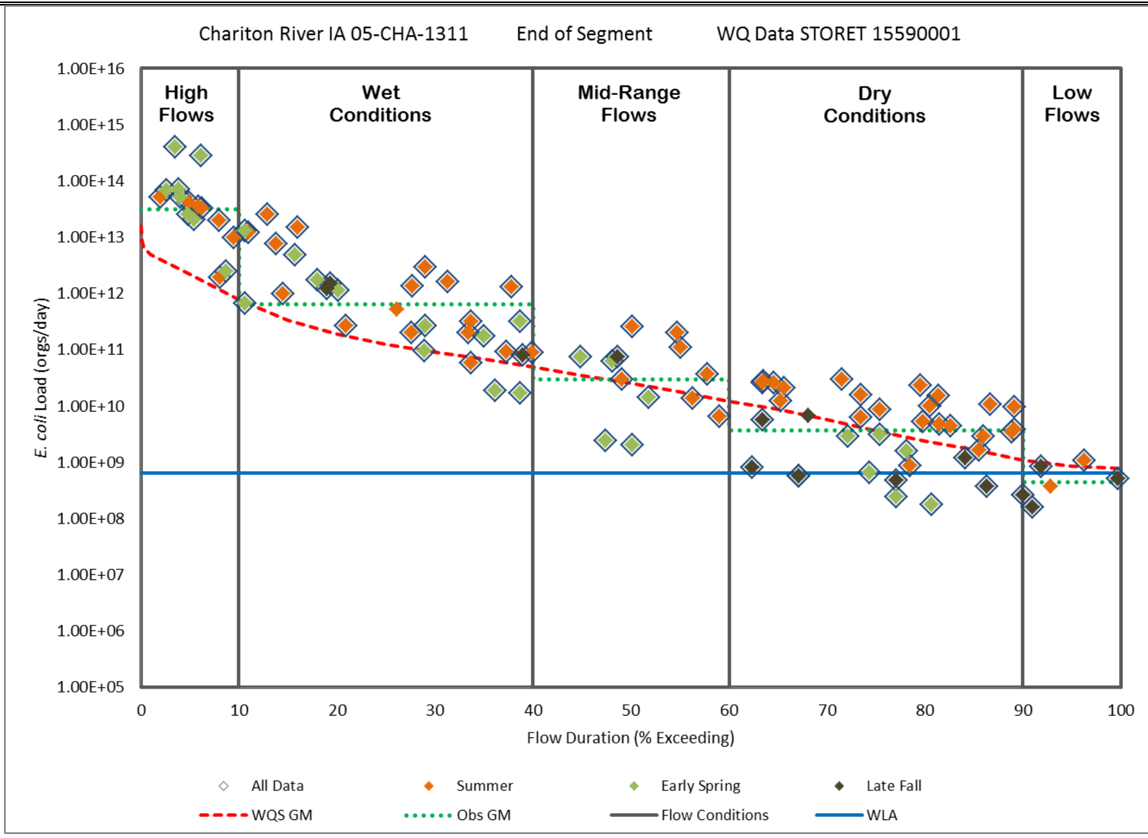

Figure 4.4. Load duration curve for IA 05-CHA-1311

Table 4.7. Existing loads estimates for IA 05-CHA-1311

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	3.17E+13	6.46E+11	2.96E+10	3.68E+09	4.39E+08
GM Departure (% Reduction)	2.96E+13 (93)	5.20E+11 (81)	4.31E+09 (15)	5.40E+07 (1.5)	-4.01E+08 (0)
Midpoint Flow (cfs)	695.1	40.8	8.2	1.2	0.3

Table 4.8. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1311

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	2.14E+12	1.26E+11	2.53E+10	3.63E+09	8.41E+08
WLA (orgs/day)	6.44E+08	6.44E+08	6.44E+08	6.44E+08	6.44E+08
LA (orgs/day)	1.93E+12	1.12E+11	2.21E+10	2.62E+09	1.13E+08
MOS (orgs/day)	2.14E+11	1.26E+10	2.53E+09	3.63E+08	8.41E+07

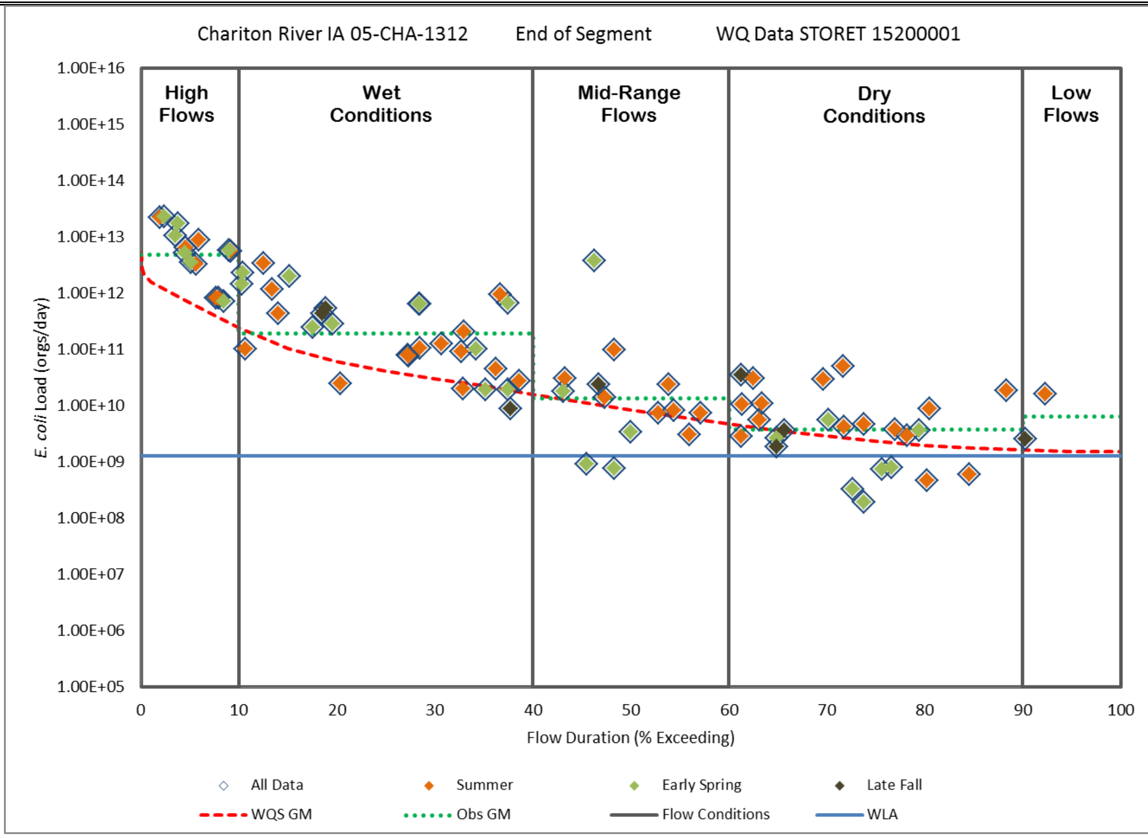

Figure 4.5. Load duration curve for IA 05-CHA-1312

Table 4.9. Existing loads estimates for IA 05-CHA-1312

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	4.96E+12	1.94E+11	1.34E+10	3.86E+09	6.51E+09
GM Departure (% Reduction)	4.28E+12 (86)	1.52E+11 (78)	4.82E+09 (36)	1.51E+09 (39)	4.94E+09 (76)
Midpoint Flow (cfs)	219.0	13.7	2.8	0.8	0.5

Table 4.10. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1312

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	6.75E+11	4.21E+10	8.60E+09	2.36E+09	1.57E+09
WLA (orgs/day)	1.28E+09	1.28E+09	1.28E+09	1.28E+09	1.28E+09
LA (orgs/day)	6.06E+11	3.67E+10	6.46E+09	8.41E+08	1.31E+08
MOS (orgs/day)	6.75E+10	4.21E+09	8.60E+08	2.36E+08	1.57E+08

Figure 4.6. Load duration curve for IA 05-CHA-1313

Table 4.11. Existing loads estimates for IA 05-CHA-1313

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	1.91E+12	5.81E+10	8.85E+09	8.80E+08	2.17E+08
GM Departure (% Reduction)	1.52E+12 (80)	3.48E+10 (60)	4.76E+09 (54)	3.59E+08 (41)	1.47E+08 (68)
Midpoint Flow (cfs)	124.8	7.5	1.3	0.2	0.023

Table 4.12. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1313

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	3.85E+11	2.33E+10	4.09E+09	5.21E+08	7.06E+07
WLA (orgs/day)	5.72E+07	5.72E+07	5.72E+07	5.72E+07	5.72E+07
LA (orgs/day)	3.46E+11	2.09E+10	3.62E+09	4.12E+08	6.30E+06
MOS (orgs/day)	3.85E+10	2.33E+09	4.09E+08	5.21E+07	7.06E+06

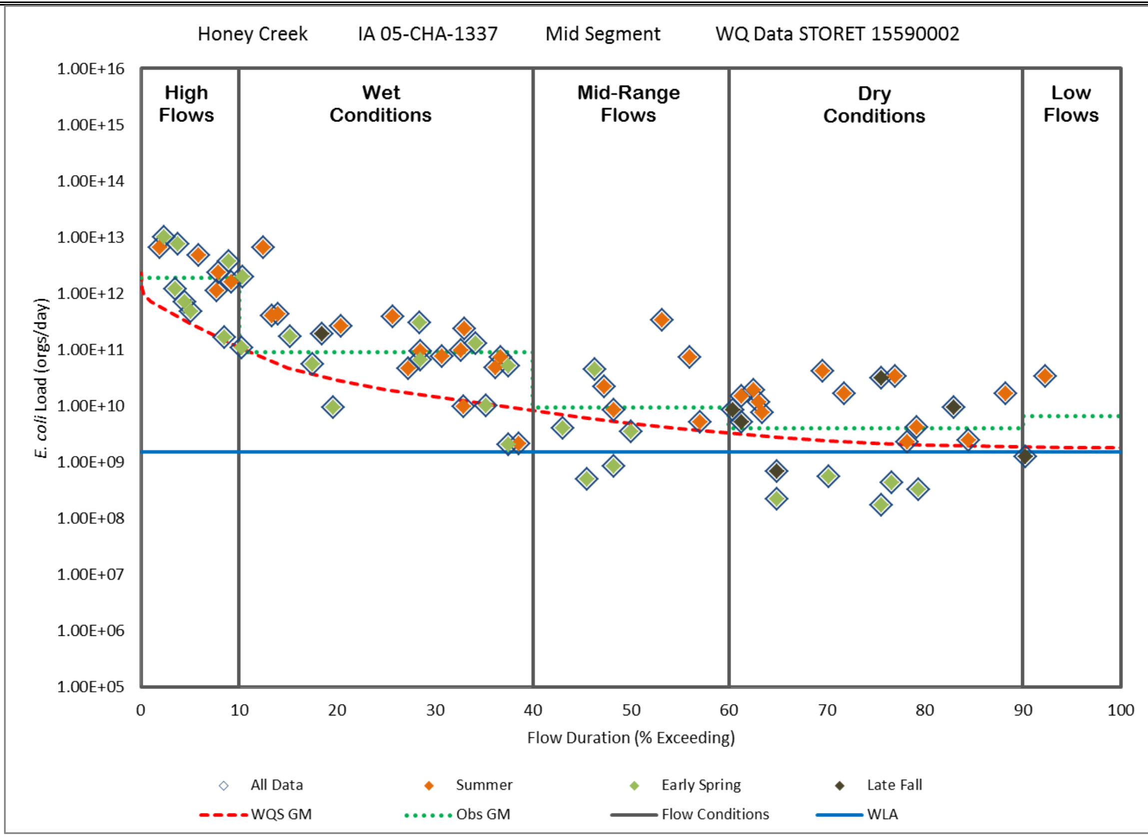

Figure 4.7. Load duration curve for IA 05-CHA-1337.

Table 4.13. Existing loads estimates for IA 05-CHA-1337

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	1.92E+12	8.99E+10	9.54E+09	4.05E+09	6.52E+09
GM Departure (% Reduction)	1.62E+12 (84)	7.02E+10 (78)	4.62E+09 (48)	1.87E+09 (46)	4.69E+09 (72)
Midpoint Flow (cfs)	96.8	6.4	1.6	0.7	0.6

Table 4.14. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1337

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	2.98E+11	1.97E+10	4.92E+09	2.18E+09	1.83E+09
WLA (orgs/day)	1.51E+09	1.51E+09	1.51E+09	1.51E+09	1.51E+09
LA (orgs/day)	2.67E+11	1.62E+10	2.92E+09	4.49E+08	1.36E+08
MOS (orgs/day)	2.98E+10	1.97E+09	4.92E+08	2.18E+08	1.83E+08

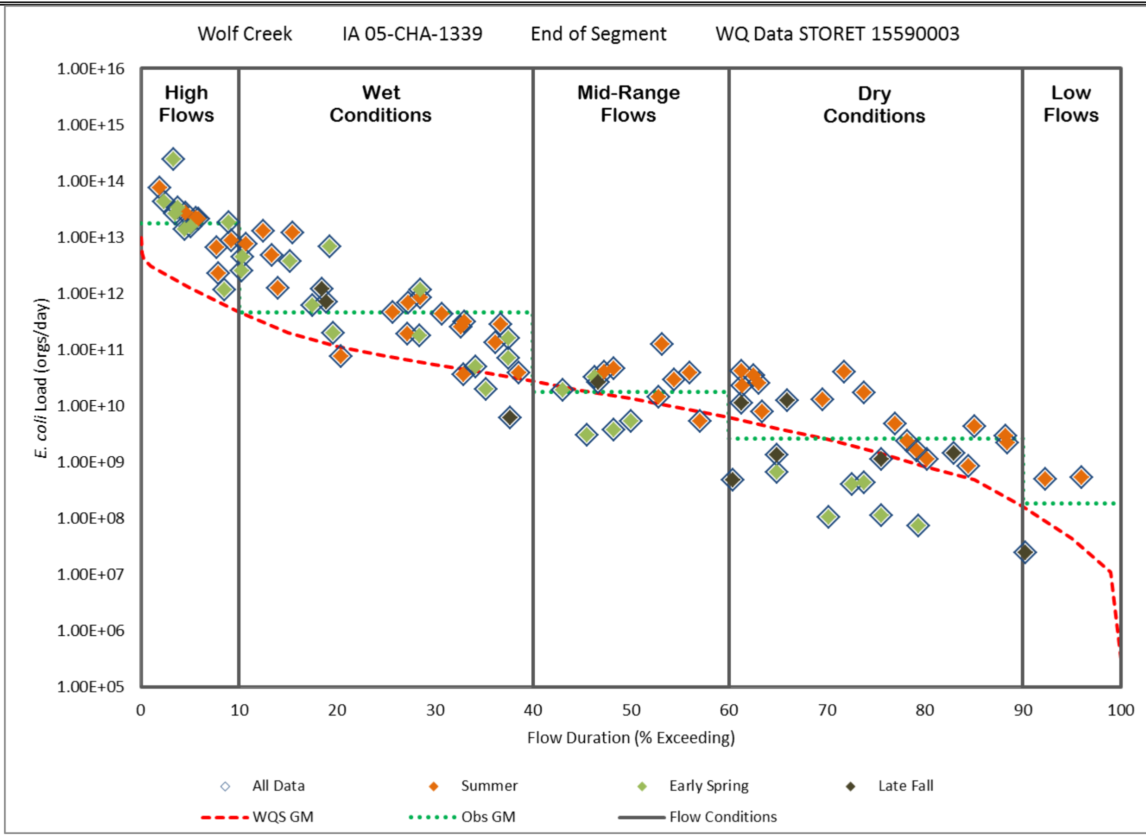

Figure 4.8. Load duration curve for IA 05-CHA-1339.

Table 4.15. Existing loads estimates for IA 05-CHA-1339

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	1.75E+13	4.62E+11	1.79E+10	2.59E+09	1.87E+08
GM Departure (% Reduction)	1.63E+13 (93)	3.85E+11 (83)	4.51E+09 (25)	1.05E+09 (41)	1.43E+08 (76)
Midpoint Flow (cfs)	414.5	25.0	4.3	0.5	0.014

Table 4.16. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1339

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	1.28E+12	7.70E+10	1.34E+10	1.54E+09	4.42E+07
WLA (orgs/day)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA (orgs/day)	1.15E+12	6.93E+10	1.20E+10	1.39E+09	3.98E+07
MOS (orgs/day)	1.28E+11	7.70E+09	1.34E+09	1.54E+08	4.42E+06

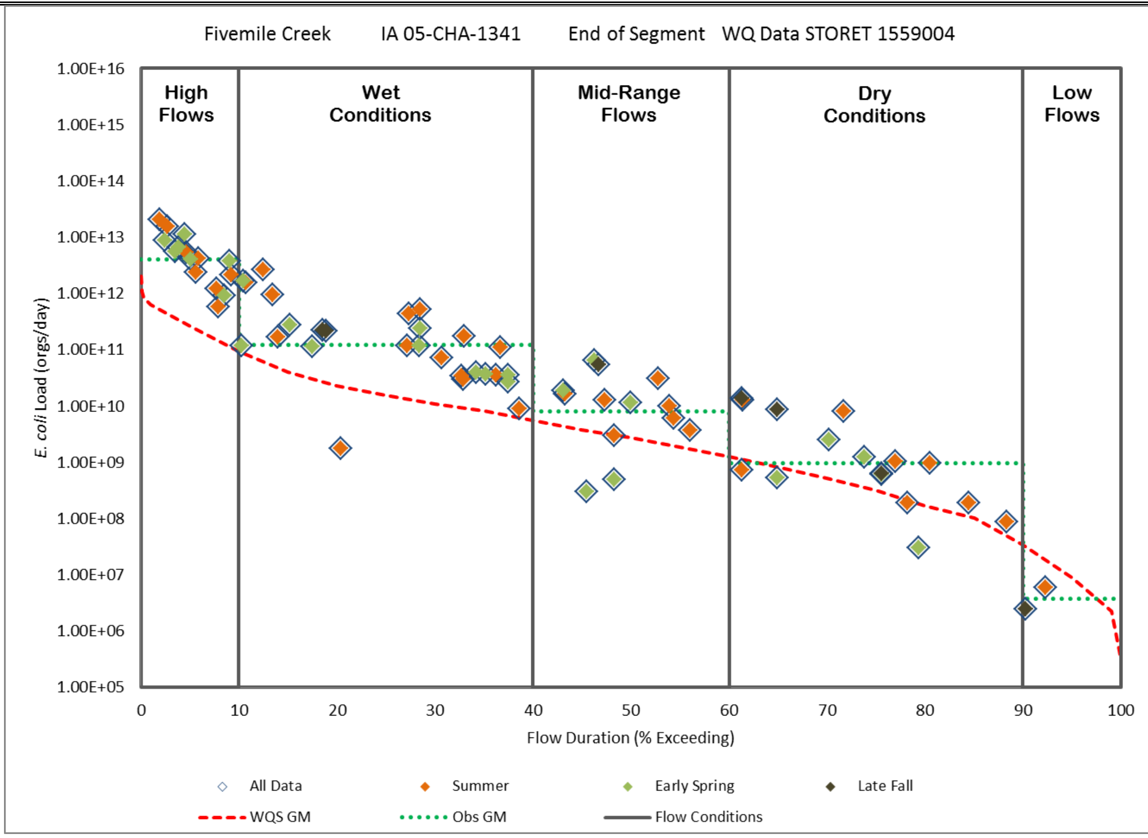

Figure 4.9. Load duration curve for IA 05-CHA-1341.

Table 4.17. Existing loads estimates for IA 05-CHA-1341

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	4.06E+12	1.21E+11	7.94E+09	9.59E+08	3.82E+06
GM Departure (% Reduction)	3.80E+12 (94)	1.05E+11 (87)	5.22E+09 (65)	6.46E+08 (67)	-5.17E+06 (0)
Midpoint Flow (cfs)	84.2	5.1	0.9	0.1	0.003

Table 4.18. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1341

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	2.60E+11	1.57E+10	2.72E+09	3.13E+08	8.99E+06
WLA (orgs/day)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA (orgs/day)	2.34E+11	1.41E+10	2.45E+09	2.82E+08	8.09E+06
MOS (orgs/day)	2.60E+10	1.57E+09	2.72E+08	3.13E+07	8.99E+05

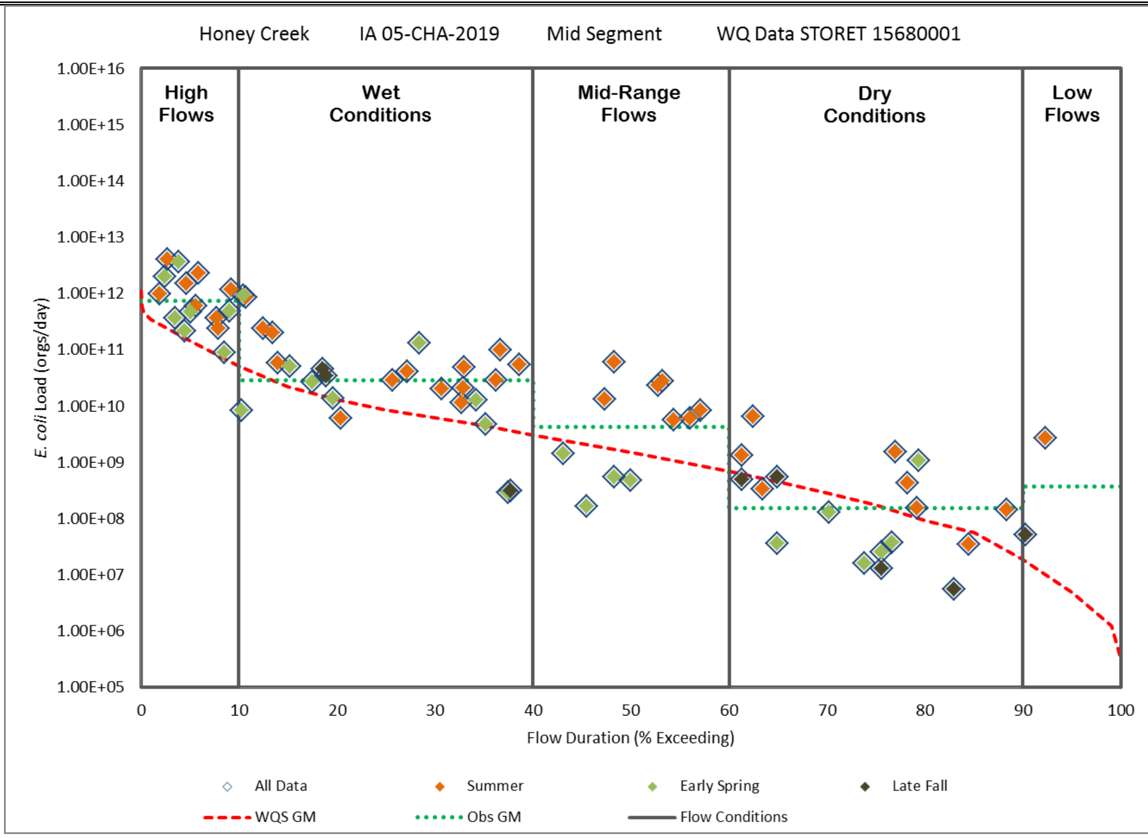

Figure 4.10. Load duration curve for IA 05-CHA-2019.

Table 4.19. Existing loads estimates for IA 05-CHA-2019

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	7.36E+11	2.89E+10	4.31E+09	1.53E+08	3.69E+08
GM Departure (% Reduction)	5.93E+11 (81)	2.03E+10 (70)	2.81E+09 (65)	-1.99E+07 (0)	3.64E+08 (99)
Midpoint Flow (cfs)	46.4	2.8	0.5	0.1	0.002

Table 4.20. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-2019

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	1.43E+11	8.63E+09	1.50E+09	1.73E+08	4.96E+06
WLA (orgs/day)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA (orgs/day)	1.29E+11	7.77E+09	1.35E+09	1.55E+08	4.46E+06
MOS (orgs/day)	1.43E+10	8.63E+08	1.50E+08	1.73E+07	4.96E+05

4.4 TMDL Summary

The following equation represents the total maximum daily load (TMDL) and its components for the impaired segments of the Wolf Creek-Chariton River HUC 10:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

Where: TMDL = total maximum daily load
LC = loading capacity
∑WLA = sum of wasteload allocations (point sources)
∑LA = sum of load allocations (nonpoint sources)
MOS = margin of safety (to account for uncertainty)

Once the loading capacity, wasteload allocations, load allocations, and margin of safety have all been determined, the general equation above can be expressed for each segment and flow condition for *E. coli* as the allowable maximum daily load (Table 4.21) as required by EPA (see Appendix D).

Table 4.21. TMDL summary by impaired segment for the Wolf Creek-Chariton River HUC 10.

Flow Condition	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
Chariton River (IA 05-CHA-1310)				
High Flow	4.39E+12	0.00E+00	3.95E+12	4.39E+11
Wet	2.65E+11	0.00E+00	2.38E+11	2.65E+10
Average	4.60E+10	0.00E+00	4.14E+10	4.60E+09
Dry	5.29E+09	0.00E+00	4.76E+09	5.29E+08
Low Flow	1.52E+08	0.00E+00	1.37E+08	1.52E+07
Chariton River (IA 05-CHA-1311)				
High Flow	2.14E+12	6.44E+08	1.93E+12	2.14E+11
Wet	1.26E+11	6.44E+08	1.12E+11	1.26E+10
Average	2.53E+10	6.44E+08	2.21E+10	2.53E+09
Dry	3.63E+09	6.44E+08	2.62E+09	3.63E+08
Low Flow	8.41E+08	6.44E+08	1.13E+08	8.41E+07
Chariton River (IA 05-CHA-1312)				
High Flow	6.75E+11	1.28E+09	6.06E+11	6.75E+10
Wet	4.21E+10	1.28E+09	3.67E+10	4.21E+09
Average	8.60E+09	1.28E+09	6.46E+09	8.60E+08
Dry	2.36E+09	1.28E+09	8.41E+08	2.36E+08
Low Flow	1.57E+09	1.28E+09	1.31E+08	1.57E+08
Chariton Creek (IA 05-CHA-1313)				
High Flow	3.85E+11	5.72E+07	3.46E+11	3.85E+10
Wet	2.33E+10	5.72E+07	2.09E+10	2.33E+09
Average	4.09E+09	5.72E+07	3.62E+09	4.09E+08
Dry	5.21E+08	5.72E+07	4.12E+08	5.21E+07
Low Flow	7.06E+07	5.72E+07	6.30E+06	7.06E+06

Flow Condition	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
Honey Creek (IA 05-CHA-1337)				
High Flow	2.98E+11	1.51E+09	2.67E+11	2.98E+10
Wet	1.97E+10	1.51E+09	1.62E+10	1.97E+09
Average	4.92E+09	1.51E+09	2.92E+09	4.92E+08
Dry	2.18E+09	1.51E+09	4.49E+08	2.18E+08
Low Flow	1.83E+09	1.51E+09	1.36E+08	1.83E+08
Wolf Creek (IA 05-CHA-1339)				
High Flow	1.28E+12	0.00E+00	1.15E+12	1.28E+11
Wet	7.70E+10	0.00E+00	6.93E+10	7.70E+09
Average	1.34E+10	0.00E+00	1.20E+10	1.34E+09
Dry	1.54E+09	0.00E+00	1.39E+09	1.54E+08
Low Flow	4.42E+07	0.00E+00	3.98E+07	4.42E+06
Fivemile Creek (IA 05-CHA-1341)				
High Flow	2.60E+11	0.00E+00	2.34E+11	2.60E+10
Wet	1.57E+10	0.00E+00	1.41E+10	1.57E+09
Average	2.72E+09	0.00E+00	2.45E+09	2.72E+08
Dry	3.13E+08	0.00E+00	2.82E+08	3.13E+07
Low Flow	8.99E+06	0.00E+00	8.09E+06	8.99E+05
Honey Creek (IA 05-CHA-2019)				
High Flow	1.43E+11	0.00E+00	1.29E+11	1.43E+10
Wet	8.63E+09	0.00E+00	7.77E+09	8.63E+08
Average	1.50E+09	0.00E+00	1.35E+09	1.50E+08
Dry	1.73E+08	0.00E+00	1.55E+08	1.73E+07
Low Flow	4.96E+06	0.00E+00	4.46E+06	4.96E+05

5. Total Maximum Daily Load (TMDL) for South Fork Chariton River for Indicator Bacteria (E. coli)

Total Maximum Daily Loads (TMDLs) are required for the six impaired waterbody segments in the South Fork Chariton River HUC 10 by the Federal Clean Water Act. This section of the Water Quality Improvement Plan (WQIP) describes the pollutant, in this case Escherichia coli (*E. coli*), leading to the impairments and the maximum amount of *E. coli* the stream segments can assimilate and still support their designated uses.

5.1 Problem Identification

The primary contact recreation (Class A1) uses in Ninemile Creek, Jordan Creek, Jackson Creek, Walker Branch, and two segments of the South Fork Chariton River are not supported due to the presence of high levels of indicator bacteria (*E. coli*) (Figure 5.1). High *E. coli* levels in a waterbody can indicate the presence of potentially harmful bacteria and viruses (also called pathogens). Humans can become ill if they come into contact with and/or ingest water that contains pathogens. Under Iowa Administrative Code, streams are impaired for *E. coli* if they exceed a single sample maximum of 235 colony forming units (cfu) per 100 mL of water or the geometric mean of all samples exceeds 126 cfu/100 mL of water. This standard is only applicable during the recreation season, defined as March 15 through November 15.

Both point and nonpoint sources of pollution can be responsible for high *E. coli* levels. Permitted sources include municipal wastewater treatment facilities (WWTF) and discharging onsite wastewater treatment and disposal systems. Onsite wastewater treatment systems are often called septic systems, even though not all systems include a septic tank. Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the stream. Specific examples of potential nonpoint sources of bacteria include cattle with direct access to streams, manure applied to row crops, non-permitted onsite wastewater systems, and natural sources such as wildlife.

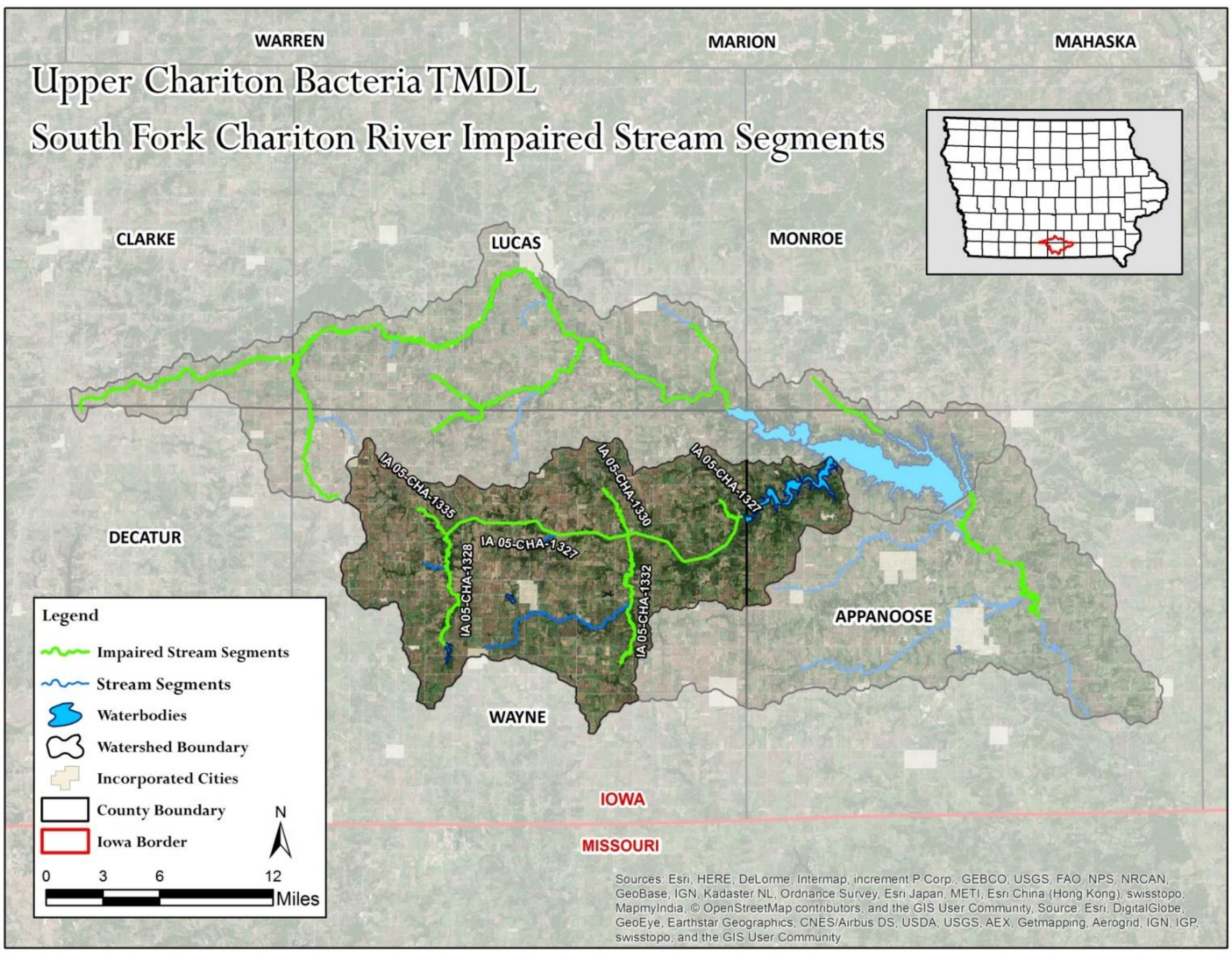

Figure 5.1. Map of the South Fork Chariton River HUC 10 with impaired stream segments.

Stream Segment Designations and Descriptions

Six stream segments within the South Fork Chariton River HUC 10 do not meet water quality standards (WQS) and are not fully supporting class A1 (primary contact) designated uses due to presence of high levels of indicator bacteria called Escherichia coli (*E. coli*). Prior to 2008, none of the listed segments were designated for primary contact recreation (Class A1). In February 2008, changes to Iowa's surface water classifications were approved by the EPA and all segments were now presumed to be Class A1, primary contact recreation. Table 5.1 is a summary of the impaired stream segments, segment identification, location description, segment length, and designated uses.

Table 5.1. Impaired stream segments and designated uses.

Stream name	Segment ID	Location Description	Stream length	Designated Uses
South Fork Chariton River	IA 05-CHA-1327	mouth (at Rathbun Lake) to confluence with Ninemile Cr. in S4, T69N, R22W, Wayne Co.	31.9 mi.	A1 B (WW2)
South Fork Chariton River	IA 05-CHA-1328	from confluence with Ninemile Cr. (S4, T69N, R22W, Wayne Co.) to outfall of Bob White Lake in S4, T68N, R22W, Wayne Co.	8.1 mi.	A1 B (WW2)
Walker Branch	IA 05-CHA-1329	mouth (S36, T70N, R20W, Wayne Co.) to confluence with S. Fork Walker Branch in SE 1/4, S26, T70N, R20W, Wayne Co.	1.5 mi.	A1 B (WW2)
Jordan Creek	IA 05-CHA-1330	mouth (S1, T70N, R21W, Wayne Co.) to confluence with unnamed tributary in E 1/2, NW 1/4, S26, T70N, R21W, Wayne Co.	3.5 mi.	A1 B (WW2)
Jackson Creek	IA 05-CHA-1332	mouth (S1, T70N, R21W, Wayne Co.) to confluence with unnamed tributary in S12, T68N, R21W, Wayne Co.	10.2 mi.	A1 B (WW2)
Ninemile Creek	IA 05-CHA-1335	mouth (S4, T69N, R22W, Wayne Co.) to confluence with unnamed tributary in S31, T70N, R22W, Wayne Co.	2.3 mi.	A1 B (WW2)

Problem Statement

Water quality assessments indicate that primary contact recreation is "not supported" in these segments due to high levels of indicator bacteria (*E. coli*) that routinely violate the state's water quality standards (Table 5.2). The significance of the impairments noted in the assessments is that desirable recreational activities, such as swimming and wading, are not adequately provided by existing water quality in the impaired segments. As a result of these findings, the Federal Clean Water Act requires that TDMLs be developed for all the impaired segments for *E. coli*.

Table 5.2. Impairment criteria for each impaired segment on past assessments

Stream name	Segment ID	Geometric mean (impairment at 126 cfu/100mL)			Single Sample Max. (235 cfu/100 mL) % samples exceeding
		2010	2011	2012	
South Fork Chariton River	IA 05-CHA-1327	794	1,368	576	68%
South Fork Chariton River	IA 05-CHA-1328	679	489	208	67%
Walker Branch	IA 05-CHA-1329	679	26	45	36%
Jordan Creek	IA 05-CHA-1330	1,317	251	656	88%
Jackson Creek	IA 05-CHA-1332	836	248	934	72%
Ninemile Creek	IA 05-CHA-1335	569	196	196	62%

Data Sources

Sources of data used in the development of this TMDL include those used in the 2014 305(b) report, several sources of additional flow and water quality data, and non-water quality related data used for model development. Monitoring sites are listed in Table 5.3. Specific data includes:

- Stream data collected by Iowa DNR Watershed Improvement Section staff for the purpose of TMDL development
- Stream data collected by U.S. Army Corps of Engineers (USACE), Kansas City District, as part of its reservoir monitoring program
- Streamflow data collected by the U.S. Geological Survey (USGS) at multiple surface water gaging stations (USGS, 2015)
- Precipitation and temperature data from the National Weather Service Cooperative Observer Program (NWS COOP) (IEM, 2015)
- Precipitation and temperature data from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) (NOAA, 2015)
- 10-m Digital Elevation Model (DEM) available from DNR GIS library
- SSURGO soils data maintained by United States Department of Agriculture -Natural Resource Conservation Service (USDA-NRCS)
- U.S. Department of Agriculture National Agricultural Statistics Service Cropland Data Layer (CDL) reflecting 2006 conditions (USDA-NASS, 2013)
- Six-year crop rotation data for 2008-2013 developed by the USDA National Laboratory for Agriculture and the Environment (USDA-NLAE) (Tomer et al., 2013)
- Aerial images (various years) collected and maintained by DNR

Table 5.3. WQ Monitoring Sites of South Fork Chariton River HUC 10.

Site Name	ID	Longitude	Latitude
S. Fork Chariton River (RA-12)	STORET 15930001	-93.1928	40.8007
S. Fork Chariton River (RA-35)	STORET 15930002	-93.4005	40.7856
Ninemile Creek at Quail Run (RA-36)	STORET 15930003	-93.4089	40.8116
Jordan Creek at CR J32 (RA-37)	STORET 15930004	-93.2218	40.8119
Walker Branch at Raccoon (RA-38)	STORET 15930005	-93.1207	40.8266
Jackson Creek at Liberty (RA-39)	STORET 15930006	-93.2132	40.7544

Interpreting the Data

Analysis of the data shows consistently high *E. coli* levels that significantly exceed both criteria set for in Iowa's water quality standards for primary contact recreation. Significant reductions in *E. coli* loading will be required to comply with the standards and fully support the designated recreational use in the impaired segments.

Identification of pollutant sources

There are a variety of *E. coli* sources in the South Fork Chariton River watershed. These sources can be divided into two categories, point and non-point sources. Point sources include municipal separate storm sewer systems (MS4s), municipal and industrial wastewater treatment facilities (WWTFs), sanitary sewer overflows (SSOs), onsite wastewater systems with permitted discharges, and animal feeding operations (AFOs) regulated as concentrated animal feeding operations (CAFOs). Nonpoint sources include wildlife, manure application to row crops, grazing livestock and small feeding operations, direct deposition by livestock in streams, and non-permitted (i.e., non-discharging) onsite wastewater systems.

Load duration curves (LDCs) were used in the development of *E. coli* TMDLs for impaired stream segments in the South Fork Chariton River Watershed (Section 5.2). The use of LDCs is helpful for understanding the importance that hydrology plays on pollutant loading. Information illustrated in LDCs provides a basic understanding of the importance of potential pollutant sources, although the approach does not offer explicit calculation of source-specific pollutant loads. However, when analyzed in conjunction with a detailed inventory of sources, LDCs can provide a quantitative means of comparing the relative importance of specific pollutant sources.

Point Sources

There are a total of three active or pending NPDES permits for waste water treatment facilities (WWTF) in this watershed. In addition, there are three unsewered communities (Confidence, Millerton, Cambria), four open feedlot animal operations, and six confined animal feeding operations (CAFOs). Figure 5.2 shows the locations of NPDES permitted wastewater facilities, concentrated animal feeding operations, unsewered communities, and private facilities that discharge under an NPDES General Permit #4. A full inventory of dischargers and their respective WLAs is provided in Appendix C.

Nonpoint Sources

The nonpoint sources of pathogen indicators include contributors that do not have localized points of release into a stream. In the watershed these sources are:

- Grazing animals
- Direct deposition of manure in streams
- Land application and subsequent runoff of manure
- Developed / urban area runoff
- Wildlife
- Faulty septic tank systems

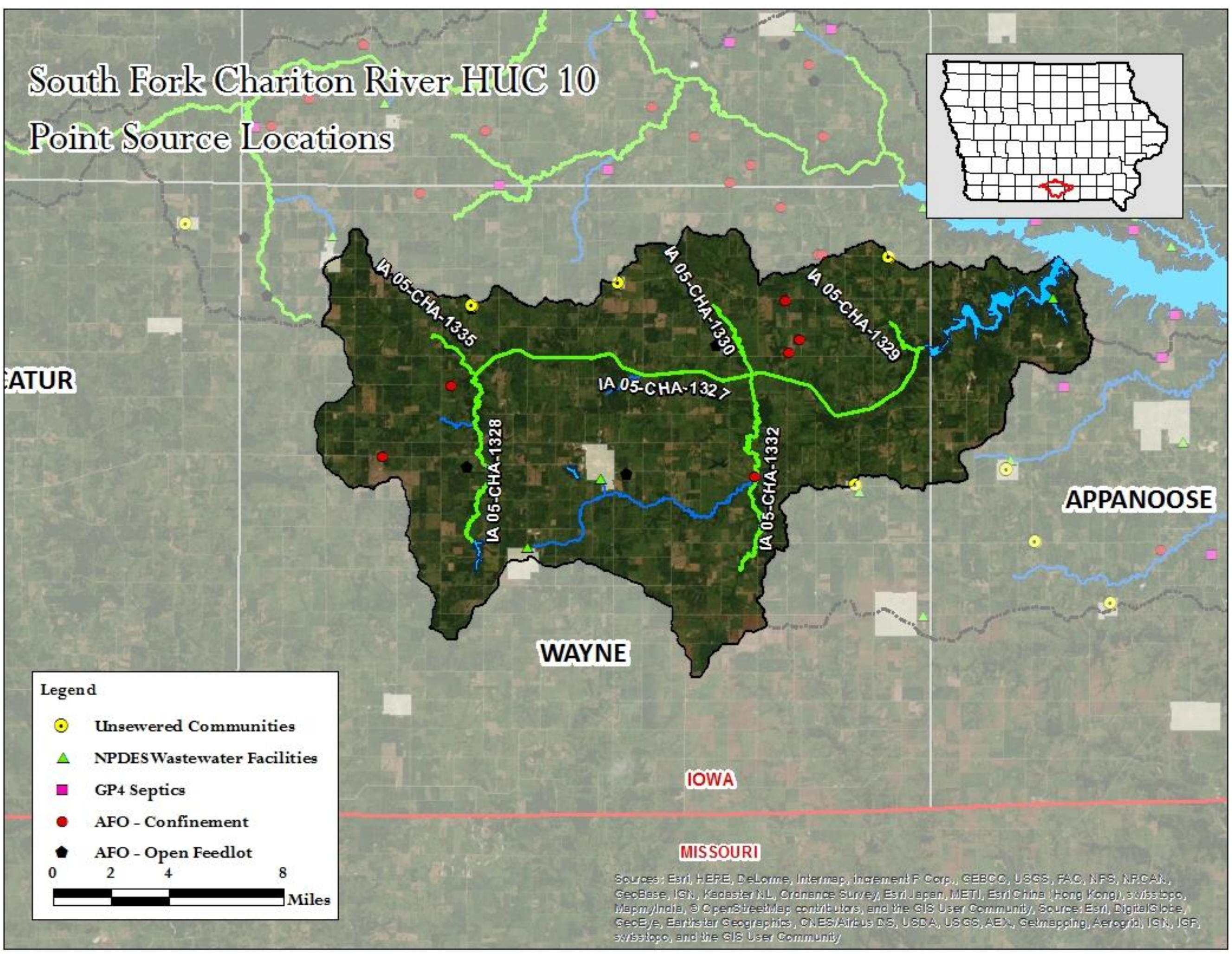

Figure 5.2. Map of the South Fork Chariton River point sources

5.2 Pollution Source Assessment

Departure from Load Capacity
The LDCs, observed loads, and observed GM loads for each flow condition are plotted in Figure 5.3 through Figure 5.8 This methodology enables calculation of a TMDL target at the midpoint of each flow condition for each impaired segment, as provided in even numbered Table 5.6 through Table 5.16.

Allowance for increases in pollutant loads
There are three unsewered communities in the south Fork Chariton River HUC 10. A reserve wasteload allocation was calculated for each community and applied to the WLA for the associated segment. Appendix C.2 lists all the unsewered communities in the Upper Chariton watershed. Any new or expanded dischargers will be expected to meet the same end-of-pipe criteria (GM of 126 orgs/100 mL) as dischargers for which WLAs were calculated and included in this TMDL.

5.3 Pollutant Allocation

Wasteload allocation
As stated previously, the wasteload allocation was calculated for each WWTP in the watershed as well as a reserve WLA for the three unsewered communities.

Table 5.4. Wasteload Allocations for South Fork Chariton River HUC-10.

Facility Type	Number of Facilities[1]	Flow (MGD)[2]	GM Conc (orgs/100 mL)	GM Load (orgs/day)
WWTF	2	1.15	126	5.47E+09
Unsewered	3	0.011	126	5.15E+07
CAFO[3]	2	--	126	0.00E+00
GP #4	0	--	126	--
Stormwater	0	--	126	--
Totals	7	1.16	126	5.52E+09

[1]Facilities in HUC 10 watershed discharging into impaired segments
[2]Flows used to calculate the wasteload allocation. See Appendix C.
[3]Facilities with 1,000 or more AU requiring a NPDES permit

Load allocation
Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the stream. Specific examples of potential nonpoint sources of bacteria include animals directly depositing into streams, manure applied to row crops, manure runoff from grazed land, non-permitted onsite wastewater systems, and natural sources such as wildlife.

Margin of Safety
An explicit margin of safety (MOS) of 10 percent is applied to the calculation of loading capacities in this TMDL.

Load Duration Curve
Figure 5.3 through Figure 5.8 show load durations for the impaired stream segments in this watershed. Table 5.5 through Table 5.16 are the existing load estimates and the TMDL summary for each impaired segment.

Figure 5.3. Load duration curve for IA 05-CHA-1327

Table 5.5. Existing loads estimates for IA 05-CHA-1327

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	8.58E+13	1.01E+12	1.45E+11	7.64E+09	2.98E+08
GM Departure (% Reduction)	8.12E+13 (95)	7.39E+11 (73)	9.20E+10 (63)	1.47E+09 (19)	1.46E+08 (49)
Midpoint Flow (cfs)	1502.3	87.6	17.2	2.0	0.05

Table 5.6. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1327

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	4.63E+12	2.70E+11	5.30E+10	6.18E+09	1.52E+08
WLA (orgs/day)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA (orgs/day)	4.17E+12	2.43E+11	4.77E+10	5.56E+09	1.36E+08
MOS (orgs/day)	4.63E+11	2.70E+10	5.30E+09	6.18E+08	1.52E+07

Figure 5.4. Load duration curve for IA 05-CHA-1328

Table 5.7. Existing loads estimates for IA 05-CHA-1328

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	1.24E+13	2.86E+11	1.47E+10	1.49E+09	2.26E+08
GM Departure (% Reduction)	1.15E+13 (93)	2.33E+11 (82)	4.31E+09 (29)	2.82E+08 (19)	1.96E+08 (87)
Midpoint Flow (cfs)	292.8	17.1	3.4	0.4	0.01

Table 5.8. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1328

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	9.03E+11	5.26E+10	1.03E+10	1.20E+09	2.95E+07
WLA (orgs/day)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LA (orgs/day)	8.12E+11	4.74E+10	9.30E+09	1.08E+09	2.66E+07
MOS (orgs/day)	9.03E+10	5.26E+09	1.03E+09	1.20E+08	2.95E+06

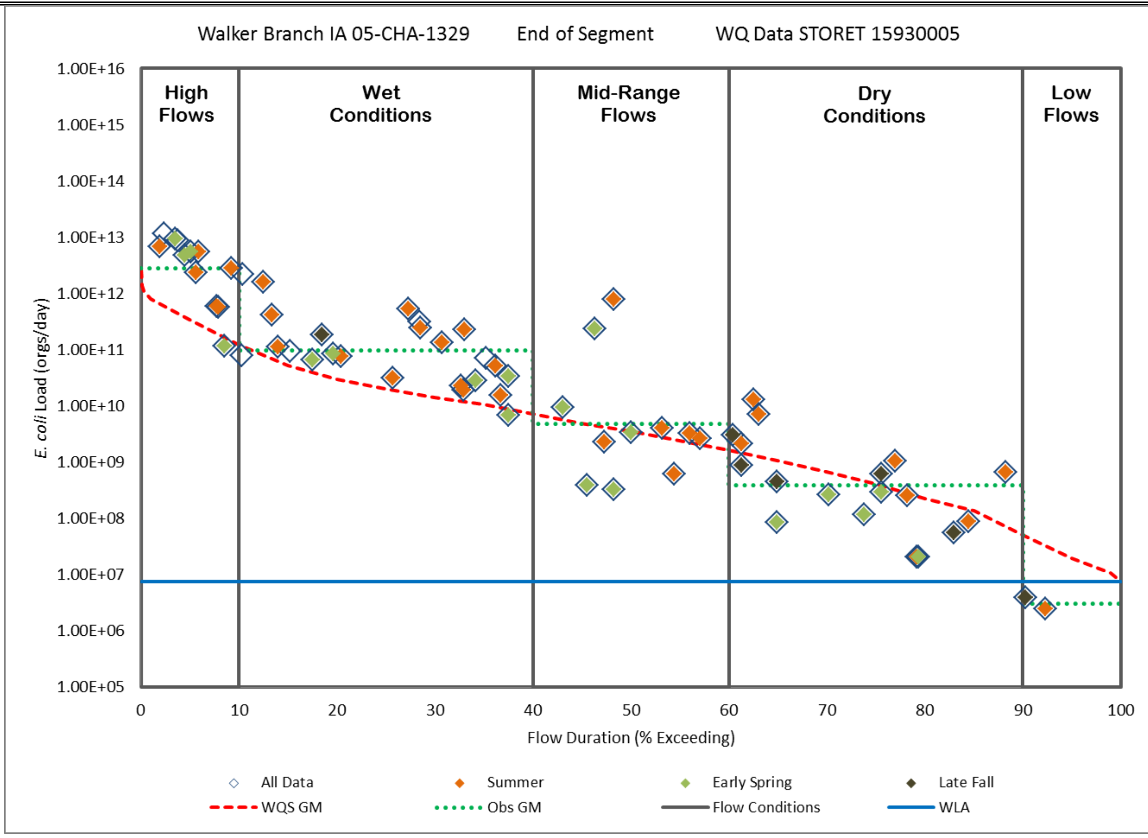

Figure 5.5. Load duration curve for IA 05-CHA-1329

Table 5.9. Existing loads estimates for IA 05-CHA-1329

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	2.80E+12	9.75E+10	4.85E+09	3.86E+08	3.07E+06
GM Departure (% Reduction)	2.46E+12 (88)	7.72E+10 (79)	1.32E+09 (27)	-2.66E+07 (0)	-1.62E+07 (0)
Midpoint Flow (cfs)	109.1	6.6	1.1	0.1	0.006

Table 5.10. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1329

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	3.36E+11	2.03E+10	3.53E+09	4.13E+08	1.93E+07
WLA (orgs/day)	7.63E+06	7.63E+06	7.63E+06	7.63E+06	7.63E+06
LA (orgs/day)	3.03E+11	1.82E+10	3.17E+09	3.64E+08	9.71E+06
MOS (orgs/day)	3.36E+10	2.03E+09	3.53E+08	4.13E+07	1.93E+06

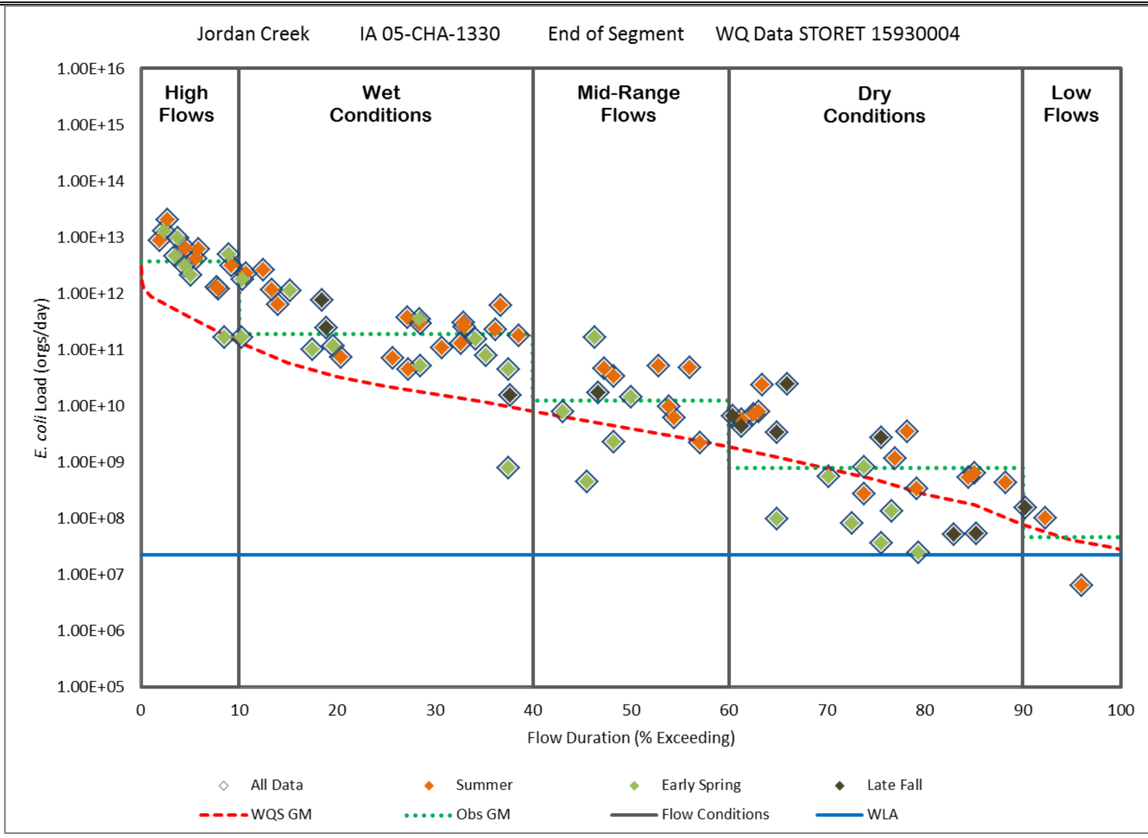

Figure 5.6. Load duration curve for IA 05-CHA-1330

Table 5.11. Existing loads estimates for IA 05-CHA-1330

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	3.74E+12	1.90E+11	1.24E+10	7.94E+08	4.71E+07
GM Departure (% Reduction)	3.37E+12 (90)	1.67E+11 (88)	8.41E+09 (68)	3.13E+08 (39)	6.28E+06 (13)
Midpoint Flow (cfs)	122.0	7.4	1.3	0.2	0.01

Table 5.12. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1330

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	3.76E+11	2.27E+10	3.97E+09	4.81E+08	4.08E+07
WLA (orgs/day)	2.29E+07	2.29E+07	2.29E+07	2.29E+07	2.29E+07
LA (orgs/day)	3.39E+11	2.04E+10	3.55E+09	4.10E+08	1.38E+07
MOS (orgs/day)	3.76E+10	2.27E+09	3.97E+08	4.81E+07	4.08E+06

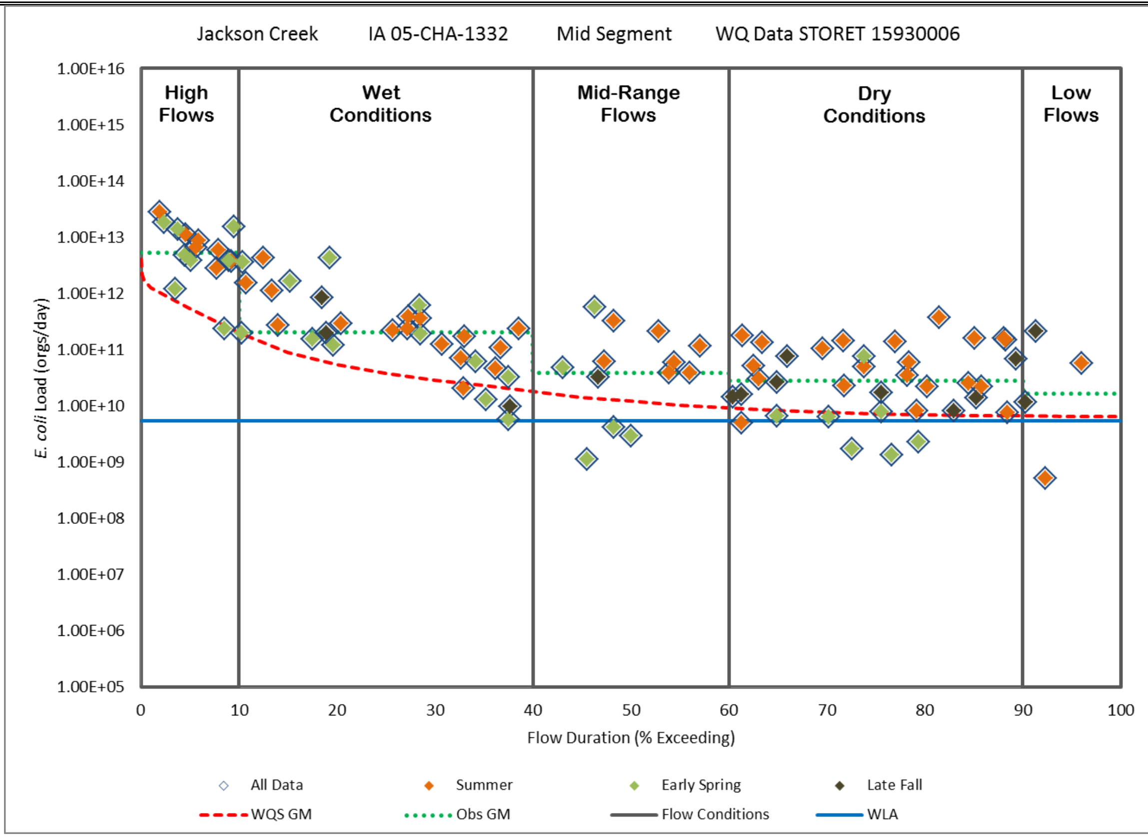

Figure 5.7. Load duration curve for IA 05-CHA-1332

Table 5.13. Existing loads estimates for IA 05-CHA-1332

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	5.36E+12	2.04E+11	3.92E+10	2.77E+10	1.64E+10
GM Departure (% Reduction)	4.82E+12 (90)	1.66E+11 (81)	2.71E+10 (69)	2.05E+10 (74)	9.86E+09 (60)
Midpoint Flow (cfs)	173.9	12.5	3.9	2.3	2.1

Table 5.14. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1332

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	5.36E+11	3.85E+10	1.21E+10	7.20E+09	6.58E+09
WLA (orgs/day)	5.47E+09	5.47E+09	5.47E+09	5.47E+09	5.47E+09
LA (orgs/day)	4.77E+11	2.92E+10	5.44E+09	1.02E+09	4.61E+08
MOS (orgs/day)	5.36E+10	3.85E+09	1.21E+09	7.20E+08	6.58E+08

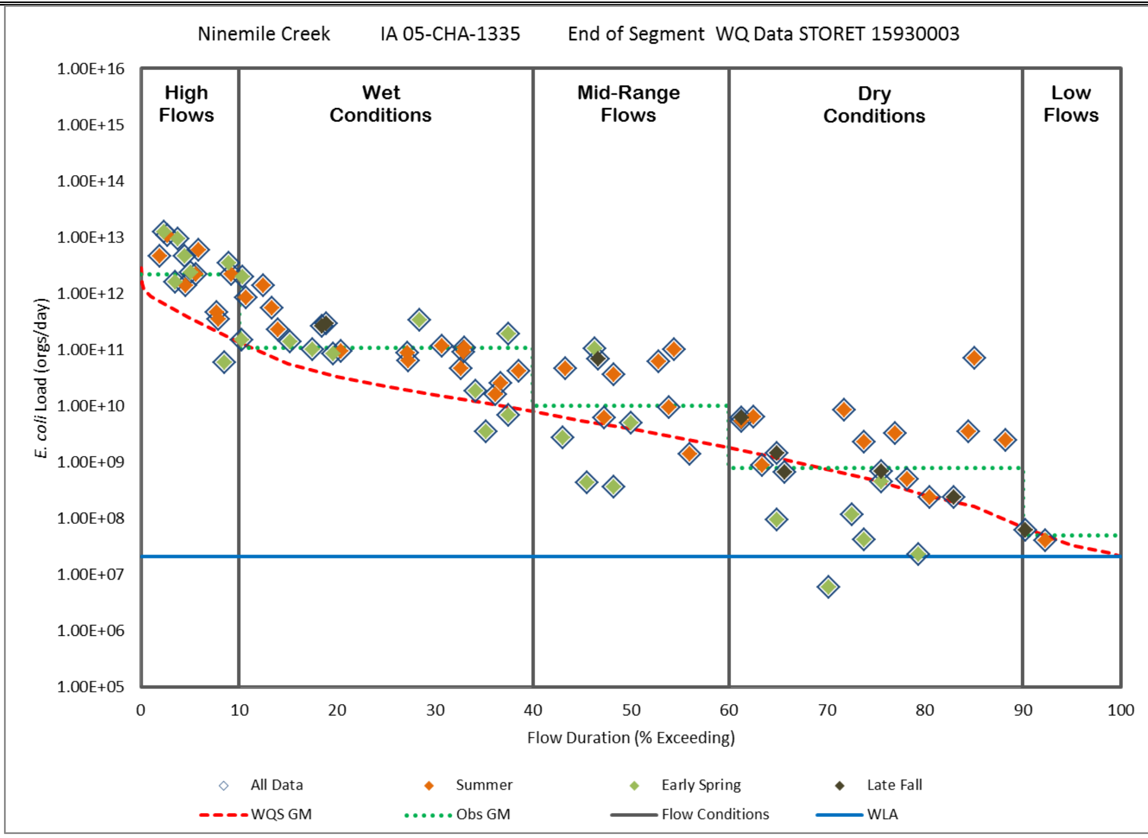

Figure 5.8. Load duration curve for IA 05-CHA-1335

Table 5.15. Existing loads estimates for IA 05-CHA-1335

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	2.19E+12	1.06E+11	1.01E+10	7.76E+08	5.04E+07
GM Departure (% Reduction)	1.82E+12 (83)	8.41E+10 (79)	6.24E+09 (62)	3.11E+08 (40)	1.66E+07 (33)
Midpoint Flow (cfs)	119.5	7.2	1.3	0.2	0.011

Table 5.16. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1335

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	3.68E+11	2.22E+10	3.88E+09	4.65E+08	3.37E+07
WLA (orgs/day)	2.10E+07	2.10E+07	2.10E+07	2.10E+07	2.10E+07
LA (orgs/day)	3.32E+11	2.00E+10	3.47E+09	3.97E+08	9.37E+06
MOS (orgs/day)	3.68E+10	2.22E+09	3.88E+08	4.65E+07	3.37E+06

5.4 TMDL Summary

The following equation represents the total maximum daily load (TMDL) and its components for the impaired segments of the Wolf Creek-Chariton River HUC 10:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

Where: TMDL = total maximum daily load
LC = loading capacity
∑ WLA = sum of wasteload allocations (point sources)
∑ LA = sum of load allocations (nonpoint sources)
MOS = margin of safety (to account for uncertainty)

Once the loading capacity, wasteload allocations, load allocations, and margin of safety have all been determined, the general equation above can be expressed for each segment and flow condition for *E. coli* as the allowable maximum daily load (Table 5.17) as required by EPA (see Appendix D).

Table 5.17. TMDL summary by impaired segment for the South Fork Chariton River HUC 10

Flow Condition	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
South Fork Chariton River (IA 05-CHA-1327)				
High Flow	4.63E+12	0.00E+00	4.17E+12	4.63E+11
Wet	2.70E+11	0.00E+00	2.43E+11	2.70E+10
Average	5.30E+10	0.00E+00	4.77E+10	5.30E+09
Dry	6.18E+09	0.00E+00	5.56E+09	6.18E+08
Low Flow	1.52E+08	0.00E+00	1.36E+08	1.52E+07
South Fork Chariton Creek (IA 05-CHA-1328)				
High Flow	9.03E+11	0.00E+00	8.12E+11	9.03E+10
Wet	5.26E+10	0.00E+00	4.74E+10	5.26E+09
Average	1.03E+10	0.00E+00	9.30E+09	1.03E+09
Dry	1.20E+09	0.00E+00	1.08E+09	1.20E+08
Low Flow	2.95E+07	0.00E+00	2.66E+07	2.95E+06
Walker Branch (IA 05-CHA-1329)				
High Flow	3.36E+11	7.63E+06	3.03E+11	3.36E+10
Wet	2.03E+10	7.63E+06	1.82E+10	2.03E+09
Average	3.53E+09	7.63E+06	3.17E+09	3.53E+08
Dry	4.13E+08	7.63E+06	3.64E+08	4.13E+07
Low Flow	1.93E+07	7.63E+06	9.71E+06	1.93E+06
Jordan Creek (IA 05-CHA-1330)				
High Flow	3.76E+11	2.29E+07	3.39E+11	3.76E+10
Wet	2.27E+10	2.29E+07	2.04E+10	2.27E+09
Average	3.97E+09	2.29E+07	3.55E+09	3.97E+08
Dry	4.81E+08	2.29E+07	4.10E+08	4.81E+07
Low Flow	4.08E+07	2.29E+07	1.38E+07	4.08E+06

Flow Condition	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
Jackson Creek (IA 05-CHA-1332)				
High Flow	5.36E+11	5.47E+09	4.77E+11	5.36E+10
Wet	3.85E+10	5.47E+09	2.92E+10	3.85E+09
Average	1.21E+10	5.47E+09	5.44E+09	1.21E+09
Dry	7.20E+09	5.47E+09	1.02E+09	7.20E+08
Low Flow	6.58E+09	5.47E+09	4.61E+08	6.58E+08
Ninemile Creek (IA 05-CHA-1335)				
High Flow	3.68E+11	2.10E+07	3.32E+11	3.68E+10
Wet	2.22E+10	2.10E+07	2.00E+10	2.22E+09
Average	3.88E+09	2.10E+07	3.47E+09	3.88E+08
Dry	4.65E+08	2.10E+07	3.97E+08	4.65E+07
Low Flow	3.37E+07	2.10E+07	9.37E+06	3.37E+06

6. Total Maximum Daily Load (TMDL) Cooper Creek - Chariton River for Indicator Bacteria (*E. coli*)

A Total Maximum Daily Load (TMDL) is required for the Cooper Creek - Chariton River segment (IA 05-CHA-1308) by the Federal Clean Water Act. This section of the Water Quality Improvement Plan (WQIP) describes the pollutant, in this case Escherichia coli (*E. coli*), leading to the impairments and the maximum amount of *E. coli* the stream segments can assimilate and still support their designated uses.

6.1 Problem Identification

The primary contact recreation (Class A1) uses in the Chariton River downstream of Rathbun Lake are not supported due to the presence of high levels of indicator bacteria (*E. coli*) (Figure 6.1). High *E. coli* levels in a waterbody can indicate the presence of potentially harmful bacteria and viruses (also called pathogens). Humans can become ill if they come into contact with and/or ingest water that contains pathogens. Under Iowa Administrative Code, streams are impaired for *E. coli* if they exceed a single sample maximum of 235 colony forming units (cfu) per 100 mL of water or the geometric mean of all samples exceeds 126 cfu/100 mL of water. This standard is only applicable during the recreation season, defined as March 15 through November 15.

Both point and nonpoint sources of pollution can be responsible for high *E. coli* levels. Permitted sources include municipal wastewater treatment facilities (WWTF) and discharging onsite wastewater treatment and disposal systems. Onsite wastewater treatment systems are often called septic systems, even though not all systems include a septic tank. Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the stream. Specific examples of potential nonpoint sources of bacteria include cattle with direct access to streams, manure applied to row crops, non-permitted onsite wastewater systems, and natural sources such as wildlife.

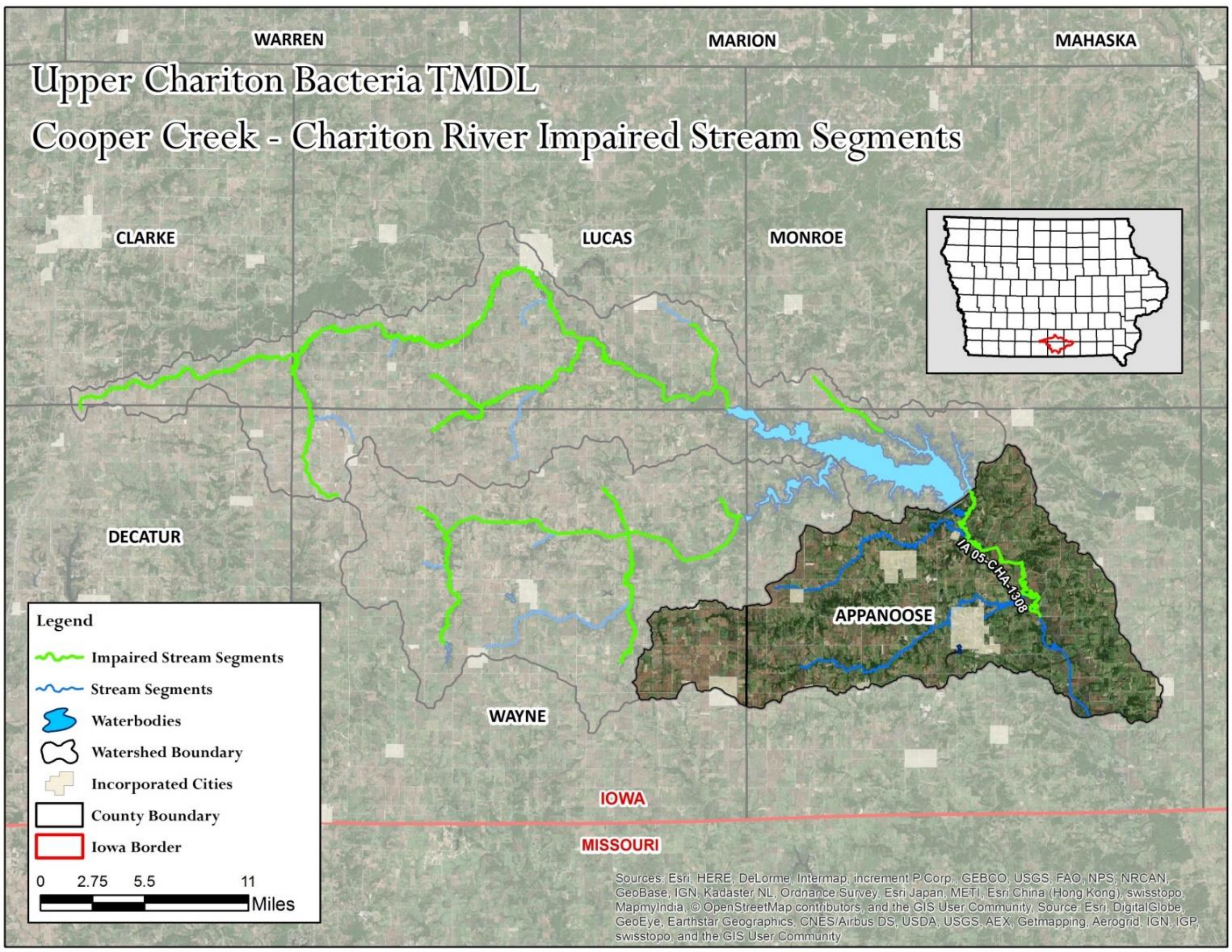

Figure 6.1. Map of the Cooper Creek - Chariton River HUC 10 with impaired stream segments.

Stream Segment Designations and Descriptions
This section of the document addresses the impairment in the Chariton River segment located downstream from the Rathbun Lake dam (Table 6.1). Prior to 2008, the listed segment was not designated for primary contact recreation (Class A1). In February 2008, changes to Iowa's surface water classifications were approved by the EPA and the segment was now presumed to be Class A1, primary contact recreation.

Table 6.1. Impaired stream segment and designated uses.

Stream name	Segment ID	Location Description	Stream length	Designated Uses
Chariton River	IA 05-CHA-1308	from the Highway 2 crossing (S27, T69N, R17W, Appanoose Co.) to Rathbun Dam in S35, T69N, R18W, Appanoose Co.	12.7 mi	A1 B (WW1)

Problem Statement
Water quality assessments indicate that primary contact recreation is "not supported" in this segment due to high levels of indicator bacteria (*E. coli*) that routinely violate the state's water quality standards (Table 6.2). The significance of the impairments noted in the assessments is that desirable recreational activities, such as swimming and wading, are not adequately provided by existing water quality in the impaired segment. As a result of these findings, the Federal Clean Water Act requires that TDMLs be developed for all the impaired segments for *E. coli*.

Table 6.2. Impairment criteria for the impaired segment

Stream name	Segment ID	Geometric mean (impairment at 126 cfu/100mL)			Single Sample Max. (235 cfu/100 mL) % samples exceeding
		2010	2011	2012	
Chariton River	IA 05-CHA-1308	31	83	235	21%

Data Sources
Sources of data used in the development of this TMDL include those used in the 2012 305(b) report, several sources of additional flow and water quality data, and non-water quality related data used for model development. Monitoring sites are listed in Table 6.3. Specific data includes:

- Precipitation and temperature data from the National Weather Service Cooperative Observer Program (NWS COOP) (IEM, 2015)
- Precipitation and temperature data from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) (NOAA, 2015)
- 10-m Digital Elevation Model (DEM) available from DNR GIS library
- SSURGO soils data maintained by United States Department of Agriculture -Natural Resource Conservation Service (USDA-NRCS)
- U.S. Department of Agriculture National Agricultural Statistics Service Cropland Data Layer (CDL) reflecting 2006 conditions (USDA-NASS, 2013)
- Aerial images (various years) collected and maintained by DNR

Table 6.3 WQ Monitoring Sites of Cooper Creek – Chariton River HUC 10.

Site Name	ID	Longitude	Latitude
S. Fork Chariton River (RA-12)	STORET 15930001	-93.1928	40.8007

Interpreting the Data
There are a variety of *E. coli* sources in the Cooper Creek - Chariton River watershed. These sources can be divided into two categories, point and non-point sources. Point sources include municipal separate storm sewer systems (MS4s), municipal and industrial wastewater treatment facilities (WWTFs), sanitary sewer overflows (SSOs), onsite wastewater systems with permitted discharges, and animal feeding operations (AFOs) regulated as concentrated animal feeding

operations (CAFOs). Nonpoint sources include wildlife, manure application to row crops, grazing livestock and small feeding operations, direct deposition by livestock in streams, and non-permitted (i.e., non-discharging) onsite wastewater systems.

Load duration curves (LDCs) were used in the development of *E. coli* TMDLs for impaired stream segments in the Cooper Creek - Chariton River Watershed (Section 6.2). The use of LDCs is helpful for understanding the importance that hydrology plays on pollutant loading. Information illustrated in LDCs provides a basic understanding of the importance of potential pollutant sources, although the approach does not offer explicit calculation of source-specific pollutant loads. However, when analyzed in conjunction with a detailed inventory of sources, LDCs can provide a quantitative means of comparing the relative importance of specific pollutant sources.

Point Sources
There are a total of eight active NPDES permits for waste water treatment facilities (WWTF) in the impaired segment of the Chariton River. In addition, there are six unsewered communities, three general purpose four (GP4) septic permits flowing to the impaired segment. There are no CAFOs reaching the threshold of 1,000 animal units, therefore there are no permitted confinement facilities in the impaired segment. Figure 6.2 shows the locations of NPDES permitted wastewater facilities, concentrated animal feeding operations, unsewered communities, and private facilities that discharge under an NPDES General Permit #4 within the HUC 10 area. A full inventory of dischargers and their respective WLAs is provided in Appendix C.

Nonpoint Sources
The nonpoint sources of pathogen indicators include contributors that do not have localized points of release into a stream. In the watershed these sources are:

- Grazing animals / wildlife
- Direct deposition of manure in streams
- Land application and subsequent runoff of manure
- Developed / urban area runoff
- Faulty septic tank systems

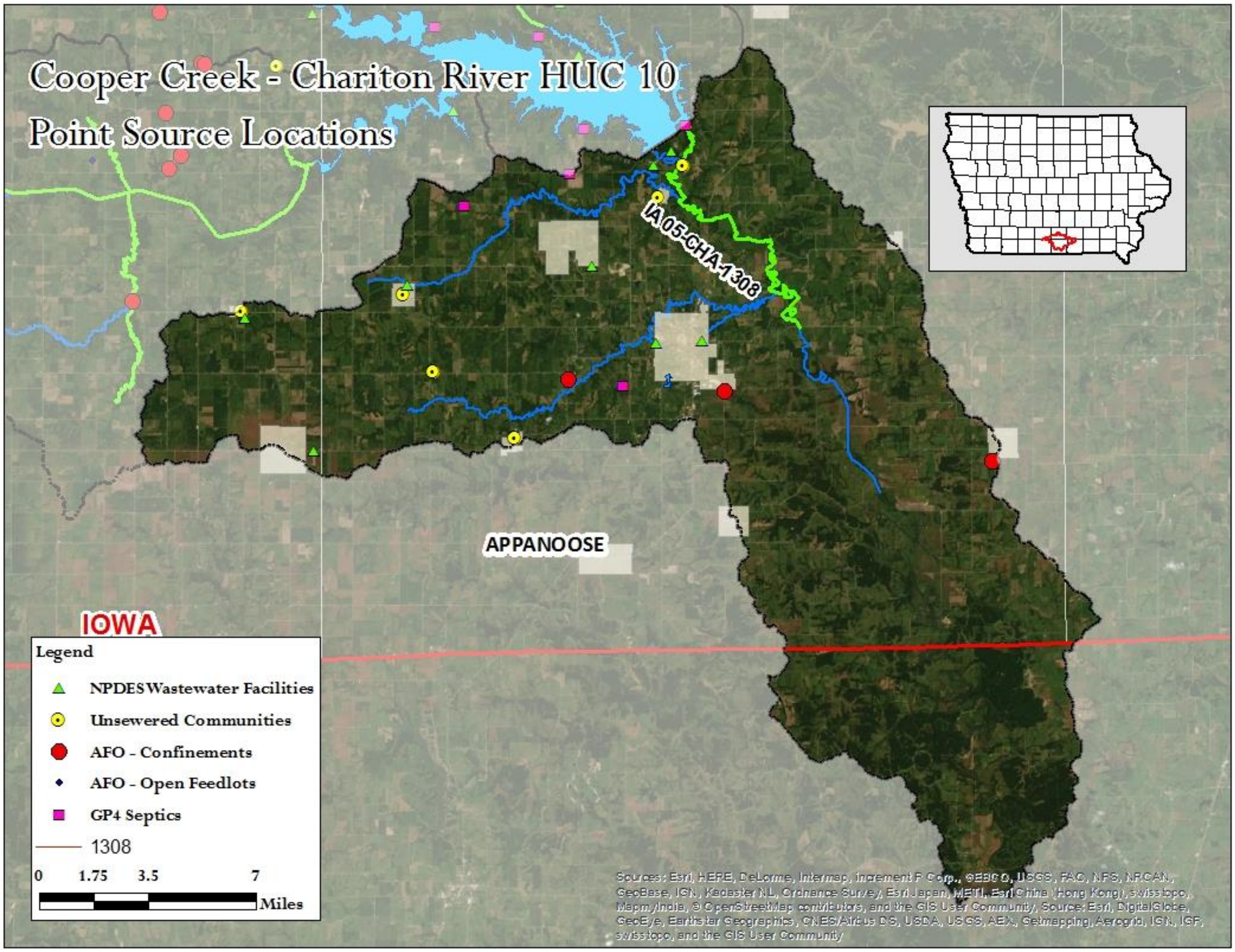

Figure 6.2. Map of the Cooper Creek - Chariton River point sources

6.2 Pollution Source Assessment

Departure from Load Capacity
The LDC, observed load, and observed GM load for each flow condition are plotted in Figure 6.3. This methodology enables calculation of a TMDL target at the midpoint of each flow condition for each impaired segment, as provided in Table 6.5.

Allowance for increases in pollutant loads
There are six unsewered communities in the Cooper Creek - Chariton River HUC 10. A reserve wasteload allocation was calculated for each community and applied to the WLA for the associated segment. Appendix C.2 lists all the unsewered communities in the Upper Chariton watershed. Any new or expanded dischargers will be expected to meet the same end-of-pipe criteria (GM of 126 orgs/100 mL) as dischargers for which WLAs were calculated and included in this TMDL.

6.3 Pollutant Allocation

Wasteload allocation

A WLA was calculated for each wastewater treatment facility (WWTF), MS4 community, and an aggregate reserve WLA for unsewered communities in the watershed. Table 6.4 shows the aggregate WLA summary by facility type for the Lower Iowa watershed. Individual WLAs for each discharger are included in Appendix C.

Table 6.4. Wasteload Allocations for Cooper Creek - Chariton River HUC-10.

Facility Type	Number of Facilities	Flow (MGD)$^{(1)}$	GM Conc (orgs/100 mL)	GM Load (orgs/day)
WWTF	8	2.16	126	1.03E+10
Unsewered	6	0.04	126	2.02E+08
AFO	0	--	126	0.00E+00
GP #4	3	--	126	--
Stormwater	0	--	126	0.00E+00
Totals	17	2.20	126	1.05E+10

Flows used to calculate the wasteload allocation. See Appendix C.

Load allocation

Nonpoint sources result from livestock, pets, wildlife, and humans that live, work, and play in and around the stream. Specific examples of potential nonpoint sources of bacteria include animals directly depositing into streams, manure applied to row crops, manure runoff from grazed land, non-permitted onsite wastewater systems, and natural sources such as wildlife.

Margin of Safety

An explicit margin of safety (MOS) of 10 percent is applied to the calculation of loading capacities in this TMDL.

Load Duration Curve

Figure 6.3 shows the load duration for the impaired stream segment in this watershed. Table 6.5 and Table 6.6 the existing load estimates and the TMDL summary for each impaired segment.

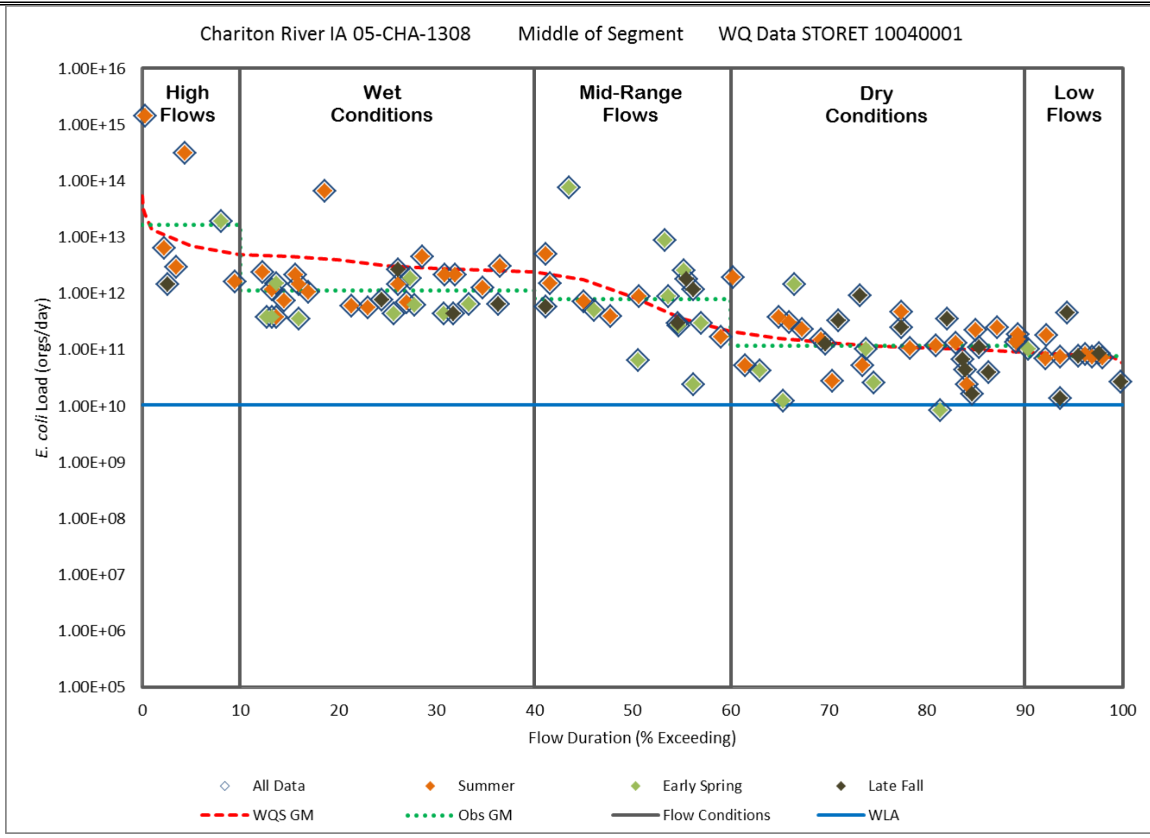

Figure 6.3. Load duration curve for IA 05-CHA-1308

Table 6.5. Existing loads estimates for IA 05-CHA-1308

Load Summary	Loads (orgs/day)				
	High	Wet	Mid-Range	Dry	Low
Obs GM	1.68E+13	1.12E+12	7.86E+11	1.18E+11	7.77E+10
GM Departure (% Reduction)	9.76E+12 (58)	-2.03E+12 (0)	-9.64E+10 (0)	1.39E+09 (1.2)	-4.53E+09 (0)
Midpoint Flow (cfs)	2283.5	1021.3	286.2	37.9	26.7

Table 6.6. Total Maximum Daily Load (TMDL) summary for IA 05-CHA-1308

Flow Condition	High	Wet	Mid-Range	Dry	Low
TMDL (orgs/day)	7.04E+12	3.15E+12	8.82E+11	1.17E+11	8.23E+10
WLA (orgs/day)	1.05E+10	1.05E+10	1.05E+10	1.05E+10	1.05E+10
LA (orgs/day)	6.33E+12	2.82E+12	7.83E+11	9.46E+10	6.36E+10
MOS (orgs/day)	7.04E+11	3.15E+11	8.82E+10	1.17E+10	8.23E+09

6.4 TMDL Summary

The following equation represents the total maximum daily load (TMDL) and its components for the impaired segment of the Chariton River:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

Where:
TMDL = total maximum daily load
LC = loading capacity
∑WLA = sum of wasteload allocations (point sources)
∑LA = sum of load allocations (nonpoint sources)
MOS = margin of safety (to account for uncertainty)

Once the loading capacity, wasteload allocations, load allocations, and margin of safety have all been determined, the general equation above can be expressed for each segment and flow condition for *E. coli* as the allowable maximum daily load (Table 6.7) as required by EPA (see Appendix F).

Table 6.7. TMDL summary by flow condition for the Chariton River

Flow Condition	TMDL (cfu/day)	WLA (cfu/day)	LA (cfu/day)	MOS (cfu/day)
Chariton River (IA 05-CHA-1308)				
High Flow	7.04E+12	1.05E+10	6.33E+12	7.04E+11
Wet	3.15E+12	1.05E+10	2.82E+12	3.15E+11
Average	8.82E+11	1.05E+10	7.83E+11	8.82E+10
Dry	1.17E+11	1.05E+10	9.46E+10	1.17E+10
Low Flow	8.23E+10	1.05E+10	6.36E+10	8.23E+09

7. Implementation Plan

An implementation plan is not a required component of a TMDL document but it is a useful and logical extension of TMDL development. It provides Iowa DNR staff, partners, and watershed stakeholders with a general idea of how a specific strategy and work plan can be developed. This strategy should guide stakeholders and the Iowa DNR in the development of a detailed and priority-based plan that implements best management practices, improves Upper Chariton River watershed water quality, and meets TMDL targets.

This water quality improvement plan sets targets for *E. coli* for the impaired segments of the Upper Chariton River Watershed. Watershed stakeholders, including municipalities and agricultural interests, will need to participate in the implementation of bacteria controls and continuing evaluation to accomplish water quality improvement goals. It will take an ongoing effort to develop best management practices in the watershed through projects funded by a variety of water quality improvement programs.

As a start, it would be useful to create a local watershed advisory committee, where none exist, to help identify high priority areas where resources can be concentrated for the greatest effect. This would facilitate the organization and provide direction for monitoring specific stream sites to identify significant pollutant sources and to plan water quality improvement activities.

7.1 General Approach & Reasonable Timeline

Collaboration and action by watershed residents, landowners, producers, business owners, and local agencies will be required to improve water quality in the Upper Chariton River Watershed to support designated uses. Locally-driven efforts have proven to be the most successful in obtaining real and significant water quality improvements. Each group has a stake in promoting awareness and educating others about the Upper Chariton River Watershed, working together to adopt a comprehensive watershed improvement plan, and applying BMPs and land practice changes in the watershed. This large and diverse group of stakeholders provides the opportunity for an effective network of partnerships to be built.

General Approach

The existing loads, loading targets and allocations, and a general menu of potential BMPs needed to improve water quality are provided in this Water Quality Improvement Plan (WQIP). The TMDL must be followed by the development of a locally-led watershed management planning process. The watershed plan should include:

- A more comprehensive and detailed assessment of potential nonpoint pollutant sources that shows the source location, magnitude, and relative impact based on proximity to streams and runoff controls in place.
- Continued monitoring to better understand and document bacteria sources.
- Application of watershed and water quality models to provide information on which best management practices will have the most impact and where they can be most effectively deployed.
- Assessment of water quality trends.
- Assessment of water quality standards (WQS) attainment.

A phased approach to improving water quality is recommended for the Upper Chariton River Watershed. Sources of bacteria, both large and small, must be reduced. However, the largest and most identifiable sources of bacteria should be given highest priority and addressed first. Less significant and/or less understood sources can be addressed later as funding allows and new monitoring data increases stakeholder understanding of their impacts to water quality.

Timeline

Development of a comprehensive watershed management plan may take one to two years from the completion of the WQIP. Implementation of BMPs could take five to ten years, depending on funding, willingness of stakeholder participation, and time needed for design and construction of structural BMPs. Realization and documentation of water quality benefits may take an additional five to ten years, depending on weather patterns, amount of water quality data collected, and the successful location, design, construction, and maintenance of BMPs. Utilization of the monitoring plan outlined in Section 8 should begin as soon as possible to help identify undocumented bacteria sources and establish a baseline. Monitoring should continue throughout implementation of BMPs and beyond to document water quality improvement.

7.2 Best Management Practices

This section provides a general summary of BMPs applicable to bacteria reduction. It is not an all-inclusive list, and further investigation (during development of the watershed management plan) may suggest that some alternatives should be implemented in favor of others. An important task in development of the watershed management plan will be to identify additional water quality improvement BMPs (both structural and non-structural), as well as prioritize, locate, and schedule implementation of BMPs.

There are two general strategies for reducing pollutant loads: source control and in-drainage reduction. Source control strategies are usually non-structural practices related to the management of runoff or production and application of pollutants (e.g., manure, fertilizer, industrial products). As the name implies, source control strategies focus on stopping or reducing the pollution at its source. Examples of source control strategies for bacteria reduction are listed in Table 7.1.

Table 7.1. Example Source Control Strategies (BMPs).

Strategy/BMP	Examples
Livestock manure management	Storage and/or treatment facilities, disposal
Manure management	Manure storage and strategic application (location, timing, and methods).
Pasture management	Elimination of stream access, grazing rotation
Septic system improvements	Inspection/repair/replacement
Wildlife management activities	Population control (particularly for geese)
Highway/roadway cleanup	Street sweeping, road kill pickup programs
Pet waste management	Educational programs, local ordinances
Low impact development (LID)[1]	LID ordinances/practices for new development
Runoff reduction[(1)]	Disconnection of impervious areas using rain barrels, porous pavement, rain gardens, etc.

[1]Some LID and runoff reduction strategies could be considered either source control or in-line drainage reduction.

In-drainage reduction strategies usually involve the use of structural BMPs to eliminate or reduce pollutants by intercepting and/or treating them within the drainage system using physical, chemical, or biological processes. Examples of in-drainage BMPs are provided in Table 7.2, along with their respective removal mechanisms.

Table 7.2. Example In-Drainage Strategies (BMPs).

Strategy/BMP	Removal Mechanism(s)[1]
Constructed wetlands	UV exposure, settling, predation
Wet detention ponds	UV exposure, settling, predation
Dry detention basin	UV exposure, settling, drying
Vegetated filter strips	Filtration, infiltration
Riparian buffers	Exclusion from stream, filtration, infiltration
Sand filters	Filtration
Infiltration trenches	Infiltration
Bioswales/bioretention	UV exposure, settling, infiltration, drying
Proprietary stormwater treatment systems[2]	Varies with device - usually settling and/or filtration

[1]Modified from North Carolina Cooperative Extension Service, 2008.
[2]Examples include hydrodynamic devices, gravity separators, and catch basin inserts.

Estimated bacteria removal efficiencies associated with the various source control BMPs are provided in Table 7.3. Table 7.4 lists removal rates associated with in-drainage BMPs. Note that these rates are highly variable. Rates listed in Table 7.3 and Table 7.4 assume that the BMP is properly designed, implemented, and maintained. Additionally, these rates apply only to the specific source of bacteria they treat, not the overall reduction. These removal rates must be applied with caution on a case-by-case basis to avoid overestimating potential water quality improvements.

Because of the large reductions required for attainment of WQS in Upper Chariton River Watershed and the highly variable nature of observed concentrations and removal, a combination of source control and in-drainage BMPs will be necessary. Additionally, many in-drainage BMPs function better when multiple systems are implemented in series. For example, grass bioswales may convey runoff to a vegetated filter strip before flows reach a constructed wetland. This type of treatment train approach offers the advantage of multiple removal mechanisms and built in redundancy to increase the reliability of bacteria reduction. The watershed management plan developed for the Upper Chariton River Watershed should consider the use of treatment train approaches wherever possible.

Table 7.3. Source Control BMPs and Estimated Bacteria Removal Rates.

BMP	Removal (%)	Additional Comments
Manure injection	Up to 90(1)	Removal will vary with injection method, application rates, land slope, weather, and other variables. Injection can offer up to 90% reduction in bacteria transport when compared to surface application.
Manure export/disposal	Up to 100	Removing manure from the watershed would provide a 100% reduction from this source. However, if manure application is increased elsewhere, impacts to that watershed must be investigated.
Exclusion of livestock from streams	Up to 100	The removal associated with this practice is proportional to the percent of livestock that are excluded. If all livestock are excluded from streams at all times, then bacteria reduction from this source would be 100%.
Septic system improvements	Up to 100	Repair/replacement of all failing systems provides 100% reduction. Watershed wide removal rate would be proportional to the percent of failing systems fixed.
Wildlife management	Varies	If there are known areas of waterfowl populations (e.g., stormwater ponds), management of geese populations would provide some bacteria reductions. Removal rates would be proportional to population reduction.
Street sweeping	Up to 22(1)	Published literature contains conflicting information regarding potential bacteria reduction from street sweeping. This BMP should not be relied upon as a key part of the implementation strategy, but may help reduce bacteria loads in highly pervious urban areas.
Pet waste management	Up to 75(1)	Includes information and education programs regarding the importance of picking up after your pets. Could include the adoption of local ordinances.
LID and runoff reduction BMPs	Varies	**Proportional to the amount of runoff reduction obtained. Some LID and runoff reduction measures are included as in-drainage BMPs in** Table 7.4.

Source: VDEQ et al., 2009

Table 7.4. In-Drainage BMPs and Estimated Bacteria Removal Rates.

BMP	Removal (%)	Additional Comments
Constructed wetlands	78-99[(2)(3)]	Wetlands could act as a source if not properly designed or maintained, including management of potential waterfowl populations.
Wet detention ponds	44-99[2,3]	Ponds could act as a source if not properly designed or maintained, including management of potential waterfowl populations.
Dry detention basins	Varies[2,3]	Dry detention basins often act as a net source of bacteria and should not be considered reliable as stand-alone systems.
Vegetated filter strips	43-57[2]	Vegetated filter strips are flat or very gently sloped segments of land intended to “treat” inflows to the stream. Filter strips should be distinguished from riparian buffers, which offer less removal potential.
Riparian buffers	Up to 40[1]	The primary benefits of buffers are to “buffer” the stream from nearby land uses and activities, as the name suggests. Actual removal rates depend on the width of the buffer and the type and density of vegetation, as well as the portion of runoff that the buffer intercepts.
Sand filters	36-83[2]	Generally designed as part of the stormwater infrastructure to capture and treat the first flush of runoff from impervious surfaces.
Bioswales and bioretention	69-99[1,2,3]	Includes rain gardens. Should be used with caution or avoided in areas where possible groundwater contamination is a concern.
Pervious concrete; porous asphalt	30-65[4]	Requires careful design and construction and is only feasible in areas with adequate soil infiltration rates (at least 0.5 inches/hour).
Permeable pavers	65-100[4]	Similar to pervious concrete and porous asphalt. Utilizes pre-cast permeable blocks to infiltrate water. Adequate soil infiltration rates required.
Hydrodynamic devices	<30[4]	Type of proprietary stormwater treatment system.
Gravity separators	<30[4]	Type of proprietary stormwater treatment system.
Coagulation and/or flocculation	65-100[4]	Chemical treatment of stormwater. Usually implemented in conjunction with a stormwater pond. Offers high removal, but addition of coagulation/flocculation chemicals such as alum is required.

[1]Source: VDEQ et al., 2009
[2]Source: EPA, 2004
[3]Source: North Carolina Cooperative Extension Service, 2008
[4]Source: Iowa Stormwater Management Manual

8. Future Monitoring

Water quality monitoring is a critical element in assessing the current status of water resources and the historical trends. Furthermore, monitoring is necessary to track the effectiveness of water quality improvements made in the watershed and document the status of the waterbody in terms of achieving total maximum daily loads and water quality standards (WQS).

Future monitoring in the Upper Chariton River watershed can be agency-led, volunteer-based, or a combination of both. The Iowa Department of Natural Resources (Iowa DNR) Watershed Monitoring and Assessment Section administers a water quality monitoring program that provides training to interested volunteers. More information can be found at the program website: http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring/Volunteer-Water-Monitoring.

It is important that volunteer-based monitoring efforts include an approved water quality monitoring plan, called a Quality Assurance Project Plan (QAPP), in accordance with Iowa Administrative Code (IAC) 567-61.10(455B) through 567-61.13(455B). The IAC can be viewed here: https://www.legis.iowa.gov/docs/iac/chapter/11-23-2016.567.61.pdf. Failure to prepare an approved QAPP will prevent data from being used to assess a waterbody's status on the state's 303(d) list - the list that assesses waterbodies and their designated uses as impaired.

Some of the monitoring projects that provided the data used to create this report are expected to be ongoing. Monitoring of Upper Chariton River bacteria are expected to continue at the ISU/ACOE sites identified in this report. Data collected at all of these sites will continue to be used by the Iowa DNR for its biannual water quality assessments (305(b) report) of the Upper Chariton River.

8.1 Monitoring Plan to Track TMDL Effectiveness

Given current resources and funding, future water quality data collection in the Upper Chariton River watershed to assess water quality trends and compliance with WQS will be limited. Unless there is local interest in collecting additional water quality data, it will be difficult to implement a watershed management plan and document TMDL effectiveness and water quality improvement with respect to bacteria.

As noted in the implementation plan, follow-up to this report requires stakeholder driven solutions and more effective management practices. Continued monitoring plays an important role in determining what practices result in load reductions and the attainment of WQS. Continued monitoring will:

- Assess the future beneficial use status;
- Determine if water quality is improving, getting worse, or staying the same;
- Evaluate the effectiveness of implemented best management practices.

Table 8.1 is an example monitoring plan.

Table 8.1. Example Monitoring Plan for Individual Segments.

Parameter(s)	Sampling Interval	Sampling Duration	Purpose
E. coli and flow	Weekly snapshot	Throughout recreation season (ongoing)	Evaluate ambient conditions
Microbial source tracking (MST)	Snapshot	At least two sampling events within recreation season. Consider one during high flow and one during low flow.	Determine the source(s) of *E. coli*
E. coli and flow (event sampling)	15-60 minutes	Throughout rising and falling limbs of hydrograph during at least two runoff events within recreation season.	Evaluate the importance of high flow conditions
E. coli and flow (dry weather sampling)	Snapshot	At least twice during low flow conditions within recreation season.	Evaluate the importance of low flow conditions

8.2 Idealized Plan for Future Watershed Projects

Future watershed improvement projects should be developed and implemented to help restore and protect water quality. If the watershed project is funded with incremental Clean Water Act Section 319 funds, the EPA requires that nine elements be addressed in the watershed plan and recommends that these nine elements be included in all other watershed plans funded through other sources (EPA, 2008). A summary of the nine elements follows. For a more detailed discussion of these elements see EPA, 2008.

1. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan.
2. An estimate of the load reductions expected from management measures.
3. A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in item 2, and a description of the critical areas in which those measures will be needed to implement this plan.
4. Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.
5. An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.
6. Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.
7. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.
8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.
9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item 8 immediately above.

Other elements that could be included in a watershed plan include, but not limited to the following:

- Complete a Use Attainability Assessment (UAA) on streams that have not been assessed. The UAA is used to determine what uses each stream can support and will help in prioritizing the streams to focus on.
- Evaluate and determine gaps in data and collecting additional data where necessary. This could include determining the location of sampling points; frequency of sampling; determining groups or individuals responsible for sampling, this could be private groups, federal, state, or local governmental agencies.
- Community education and involvement. While this was mentioned as one of the nine minimum elements it cannot be overstressed the importance to obtain local involvement.
- Review of funding availability and funding sources.
- Determination of the size or scope of the watershed plan. This report reviewed the impaired streams based on HUC-8 watershed. However, this is too large for local and community involvement. Planning should be based on a HUC-12 watershed or smaller.
- Determine the source of the impairment, point or nonpoint.
- Determine potential BMP’s for reducing and eliminating the impairment and modeling the BMP’s to identify the most efficient placement.

9. Public Participation

Public involvement is important in the TMDL process since it is the land owners, tenants, and citizens who directly manage land and live in the watershed that determine the water quality in the Upper Chariton River. During the development of this TMDL, efforts were made to ensure that local stakeholders were involved in the decision-making process regarding goals and required actions for improving water quality in the Upper Chariton River.

9.1 Public Meetings

Public Presentations

A public presentation was posted on the Iowa DNR's YouTube channel for public viewing on September 24, 2020. A link to the presentation will remain on the Iowa DNR TMDL webpage through the public comment period for the presentation.

9.2 Written Comments

A press release was issued in tandem with the posting of the presentation to the Iowa DNR's YouTube channel. The press release begins a 30 day public comment period, which will end on October 26, 2020. All public comments received during this period will be included with the corresponding official response(s) from the Iowa DNR in Appendix F.

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Appendix A - Glossary of Terms, Abbreviations, and Acronyms

303(d) list: Refers to section 303(d) of the Federal Clean Water Act, which requires a listing of all public surface waterbodies (creeks, rivers, wetlands, and lakes) that do not support their general and/or designated uses, also called the state's "Impaired Waters List."

305(b) assessment: Refers to section 305(b) of the Federal Clean Water Act, it is a comprehensive assessment of the state's public waterbodies' ability to support their general and designated uses. Those bodies of water which are found to be not supporting or only partially supporting their uses are placed on the 303(d) list.

319: Refers to Section 319 of the Federal Clean Water Act, the Nonpoint Source Management Program. Under this amendment, States receive grant money from EPA to provide technical & financial assistance, education, & monitoring to implement local nonpoint source water quality projects.

AFO: Animal Feeding Operation. A lot, yard, corral, building, or other area in which animals are confined and fed and maintained for 45 days or more in any 12-month period, and all structures used for the storage of manure from animals in the operation. Open feedlots and confinement feeding operations are considered to be separate animal feeding operations.

AU: Animal Unit. A unit of measure used to compare manure production between animal types or varying sizes of the same animal. For example, one 1,000 pound steer constitutes one AU, while one mature hog weighing 200 pounds constitutes 0.2 AU.

Benthic: Associated with or located at the bottom (in this context, "bottom" refers to the bottom of streams, lakes, or wetlands). Usually refers to algae or other aquatic organisms that reside at the bottom of a wetland, lake, or stream (see periphyton).

Benthic macroinvertebrates: Animals larger than 0.5 mm that do not have backbones. These animals live on rocks, logs, sediment, debris and aquatic plants during some period in their life. They include crayfish, mussels, snails, aquatic worms, and the immature forms of aquatic insects such as stonefly and mayfly nymphs.

Base flow: Sustained flow of a stream in the absence of direct runoff. It can include natural and human-induced stream flows. Natural base flow is sustained largely by groundwater discharges.

Biological impairment: A stream segment is classified as biologically impaired if one or more of the following occurs, the FIBI and or BMIBI scores fall below biological reference conditions, a fish kill has occurred on the segment, or the segment has seen a > 50% reduction in mussel species.

Biological reference condition: Biological reference sites represent the least disturbed (i.e. most natural) streams in the ecoregion. The biological data from these sites are used to derive least impacted BMIBI and FIBI scores for each ecoregion. These scores are used to develop Biological Impairment Criteria (BIC) scores for each ecoregion. The BIC is used to determine the impairment status for other stream segments within an ecoregion.

BMIBI: Benthic Macroinvertebrate Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of bottom-dwelling invertebrates.

BMP: Best Management Practice. A general term for any structural or upland soil or water conservation practice. For example terraces, grass waterways, sediment retention ponds, reduced tillage systems, etc.

CAFO: Concentrated Animal Feeding Operation. A federal term defined as any animal feeding operation (AFO) with more than 1000 animal units confined on site, or an AFO of any size that discharges pollutants (e.g. manure, wastewater) into any ditch, stream, or other water conveyance system, whether man-made or natural.

CBOD5: 5-day Carbonaceous Biochemical Oxygen Demand. Measures the amount of oxygen used by microorganisms to oxidize hydrocarbons in a sample of water at a temperature of 20°C and over an elapsed period of five days in the dark.

CFU: A Colony Forming Unit is a cell or cluster of cells capable of multiplying to form a colony of cells. Used as a unit of bacteria concentration when a traditional membrane filter method of analysis is used. Though not necessarily equivalent to most probably number (MPN), the two terms are often used interchangeably.

Confinement feeding operation: An animal feeding operation (AFO) in which animals are confined to areas which are totally roofed.

Credible data law: Refers to 455B.193 of the Iowa Administrative Code, which ensures that water quality data used for all purposes of the Federal Clean Water Act are sufficiently up-to-date and accurate. To be considered “credible,” data must be collected and analyzed using methods and protocols outlined in an approved Quality Assurance Project Plan (QAPP).

Cyanobacteria (blue-green algae): Members of the phytoplankton community that are not true algae but are capable of photosynthesis. Some species produce toxic substances that can be harmful to humans and pets.

Designated use(s): Refer to the type of economic, social, or ecological activities that a specific waterbody is intended to support. See Appendix B for a description of all general and designated uses.

DNR (or IOWA DNR): Iowa Department of Natural Resources.

Ecoregion: Areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources based on geology, vegetation, climate, soils, land use, wildlife, and hydrology.

EPA (or USEPA): United States Environmental Protection Agency.

Ephemeral gully erosion: Ephemeral gullies occur where runoff from adjacent slopes forms concentrated flow in drainage ways. Ephemerals are void of vegetation and occur in the same location every year. They are crossable with farm equipment and are often partially filled in by tillage.

FIBI: Fish Index of Biotic Integrity. An index-based scoring method for assessing the biological health of streams and rivers (scale of 0-100) based on characteristics of fish species.

FSA: Farm Service Agency (United States Department of Agriculture). Federal agency responsible for implementing farm policy, commodity, and conservation programs.

General use(s): Refer to narrative water quality criteria that all public waterbodies must meet to satisfy public needs and expectations. See Appendix B for a description of all general and designated uses.

Geometric Mean (GM): A statistic that is a type of mean or average (different from arithmetic mean or average) that measures central tendency of data. It is often used to summarize highly skewed data or data with extreme values such as wastewater discharges and bacteria concentrations in surface waters. In Iowa’s water quality standards and assessment procedures, the geometric mean criterion for *E. coli* is measured using at least five samples collected over a 30-day period.

GIS: Geographic Information System(s). A collection of map-based data and tools for creating, managing, and analyzing spatial information.

Groundwater: Subsurface water that occurs beneath the water table in soils and geologic formations that are fully saturated.

Gully erosion: Soil movement (loss) that occurs in defined upland channels and ravines that are typically too wide and deep to fill in with traditional tillage methods.

HEL: Highly Erodible Land. Defined by the USDA Natural Resources Conservation Service (NRCS), it is land, which has the potential for long-term annual soil losses to exceed the tolerable amount by eight times for a given agricultural field.

IDALS: Iowa Department of Agriculture and Land Stewardship

Integrated report: Refers to a comprehensive document that combines the 305(b) assessment with the 303(d) list, as well as narratives and discussion of overall water quality trends in the state's public waterbodies. The Iowa Department of Natural Resources submits an integrated report to the EPA biennially in even numbered years.

LA: Load Allocation. The portion of the loading capacity attributed to (1) the existing or future nonpoint sources of pollution and (2) natural background sources. Wherever possible, nonpoint source loads and natural loads should be distinguished. (The total pollutant load is the sum of the wasteload and load allocations.)

LiDAR: Light Detection and Ranging. Remote sensing technology that uses laser scanning to collect height or elevation data for the earth's surface.

Load: The total amount of pollutants entering a waterbody from one or multiple sources, measured as a rate, as in weight per unit time or per unit area.

Macrophyte: An aquatic plant that is large enough to be seen with the naked eye and grows either in or near water. It can be floating, completely submerged (underwater), or partially submerged.

MOS: Margin of Safety. A required component of the TMDL that accounts for the uncertainty in the response of the water quality of a waterbody to pollutant loads.

MPN: Most Probable Number. Used as a unit of bacteria concentration when a more rapid method of analysis (such as Colisure or Colilert) is utilized. Though not necessarily equivalent to colony forming units (CFU), the two terms are often used interchangeably.

MS4: Municipal Separate Storm Sewer System. A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) owned and operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under state law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act (CWA) that discharges to waters of the United States.

Nonpoint source pollution: Pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related either to land or water use including failing septic tanks, improper animal-keeping practices, forestry practices, and urban and rural runoff.

NPDES: National Pollution Discharge Elimination System. The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under Section 307, 402, 318, and 405 of the Clean Water Act. Facilities subjected to NPDES permitting regulations include operations such as municipal wastewater treatment plants and industrial waste treatment facilities, as well as some MS4s.

NRCS: Natural Resources Conservation Service (United States Department of Agriculture). Federal agency that provides technical assistance for the conservation and enhancement of natural resources.

Open feedlot: An unroofed or partially roofed animal feeding operation (AFO) in which no crop, vegetation, or forage growth or residue cover is maintained during the period that animals are confined in the operation.

Periphyton: Algae that are attached to substrates (rocks, sediment, wood, and other living organisms). Are often located at the bottom of a wetland, lake, or stream.

Phytoplankton: Collective term for all photosynthetic organisms suspended in the water column. Includes many types of algae and cyanobacteria.

Point source pollution: Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources are generally regulated by a federal NPDES permit.

Pollutant: As defined in Clean Water Act section 502(6), a pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

Pollution: The man-made or man-induced alteration of the chemical, physical, biological, and/or radiological integrity of water.

PPB: Parts per Billion. A measure of concentration that is the same as micrograms per liter (µg/L).

PPM: Parts per Million. A measure of concentration that is the same as milligrams per liter (mg/L).

RASCAL: Rapid Assessment of Stream Conditions Along Length. RASCAL is a global positioning system (GPS) based assessment procedure designed to provide continuous stream and riparian condition data at a watershed scale.

Riparian: Refers to areas near the banks of natural courses of water. Features of riparian areas include specific physical, chemical, and biological characteristics that differ from upland (dry) sites. Usually refers to the area near a bank of a stream or river.

RUSLE: Revised Universal Soil Loss Equation. An empirical model for estimating long term, average annual soil losses due to sheet and rill erosion.

Scientific notation: See explanation on page 107.

Secchi disk: A device used to measure transparency in waterbodies. The greater the Secchi depth (typically measured in meters), the more transparent the water.

Sediment delivery ratio: A value, expressed as a percent, which is used to describe the fraction of gross soil erosion that is delivered to the waterbody of concern.

Seston: All particulate matter (organic and inorganic) suspended in the water column.

SHL: State Hygienic Laboratory (University of Iowa). Provides physical, biological, and chemical sampling for water quality purposes in support of beach monitoring, ambient monitoring, biological reference monitoring, and impaired water assessments.

Sheet & rill erosion: Sheet and rill erosion is the detachment and removal of soil from the land surface by raindrop impact, and/or overland runoff. It occurs on slopes with overland flow and where runoff is not concentrated.

Single-Sample Maximum (SSM): A water quality standard criterion used to quantify *E. coli* levels. The single-sample maximum is the maximum allowable concentration measured at a specific point in time in a waterbody.

SI: Stressor Identification. A process by which the specific cause(s) of a biological impairment to a waterbody can be determined from cause-and-effect relationships.

Storm flow (or stormwater): The discharge (flow) from surface runoff generated by a precipitation event. *Stormwater* generally refers to runoff that is routed through some artificial channel or structure, often in urban areas.

STP: Sewage Treatment Plant. General term for a facility that treats municipal sewage prior to discharge to a waterbody according to the conditions of an NPDES permit.

SWCD: Soil and Water Conservation District. Agency that provides local assistance for soil conservation and water quality project implementation, with support from the Iowa Department of Agriculture and Land Stewardship.

TDS: Total Dissolved Solids: The quantitative measure of matter (organic and inorganic material) dissolved, rather than suspended, in the water column. TDS is analyzed in a laboratory and quantifies the material passing through a filter and dried at 180 degrees Celsius.

TMDL: Total Maximum Daily Load. As required by the Federal Clean Water Act, a comprehensive analysis and quantification of the maximum amount of a particular pollutant that a waterbody can tolerate while still meeting its general and designated uses. A TMDL is mathematically defined as the sum of all individual wasteload allocations (WLAs), load allocations (LAs), and a margin of safety (MOS).

Trophic state: The level of ecosystem productivity, typically measured in terms of algal biomass.

TSI (or Carlson's TSI): Trophic State Index. A standardized scoring system developed by Carlson (1977) that places trophic state on an exponential scale of Secchi depth, chlorophyll, and total phosphorus. TSI ranges between 0 and 100, with 10 scale units representing a doubling of algal biomass.

TSS: Total Suspended Solids. The quantitative measure of matter (organic and inorganic material) suspended, rather than dissolved, in the water column. TSS is analyzed in a laboratory and quantifies the material retained by a filter and dried at 103 to 105 degrees Celsius.

Turbidity: A term used to indicate water transparency (or lack thereof). Turbidity is the degree to which light is scattered or absorbed by a fluid. In practical terms, highly turbid waters have a high degree of cloudiness or murkiness caused by suspended particles.

UAA: Use Attainability Analysis. A protocol used to determine which (if any) designated uses apply to a particular waterbody. (See Appendix B for a description of all general and designated uses.)

USDA: United States Department of Agriculture

USGS: United States Geologic Survey (United States Department of the Interior). Federal agency responsible for implementation and maintenance of discharge (flow) gauging stations on the nation's waterbodies.

Watershed: The land area that drains water (usually surface water) to a particular waterbody or outlet.

WLA: Wasteload Allocation. The portion of a receiving waterbody's loading capacity that is allocated to one of its existing or future point sources of pollution (e.g., permitted waste treatment facilities).

WQS: Water Quality Standards. Defined in Chapter 61 of Environmental Protection Commission [567] of the Iowa Administrative Code, they are the specific criteria by which water quality is gauged in Iowa.

WWTF: Wastewater Treatment Facility. General term for a facility that treats municipal, industrial, or agricultural wastewater for discharge to public waters according to the conditions of the facility's NPDES permit. Used interchangeably with wastewater treatment plant (WWTP).

Zooplankton: Collective term for all animal plankton suspended in the water column which serve as secondary producers in the aquatic food chain and the primary food source for larger aquatic organisms.

Scientific Notation

Scientific notation is the way that scientists easily handle very large numbers or very small numbers. For example, instead of writing 45,000,000,000 we write 4.5E+10. So, how does this work?

We can think of 4.5E+10 as the product of two numbers: 4.5 (the digit term) and E+10 (the exponential term). Here are some examples of scientific notation.

10,000 = 1E+4	24,327 = 2.4327E+4
1,000 = 1E+3	7,354 = 7.354E+3
100 = 1E+2	482 = 4.82E+2
1/100 = 0.01 = 1E-2	0.053 = 5.3E-2
1/1,000 = 0.001 = 1E-3	0.0078 = 7.8E-3
1/10,000 = 0.0001 = 1E-4	0.00044 = 4.4E-4

As you can see, the exponent is the number of places the decimal point must be shifted to give the number in long form. A **positive** exponent shows that the decimal point is shifted that number of places to the right. A **negative** exponent shows that the decimal point is shifted that number of places to the left.

Appendix B - General and Designated Uses of Iowa's Waters

Introduction

Iowa's water quality standards (WQS) (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code) provide the narrative and numerical criteria by which water bodies are judged when determining the health and quality of our aquatic ecosystems. These standards vary depending on the type of water body (lakes vs. rivers) and the assigned uses (general use vs. designated uses) of the water body that is being dealt with. This appendix is intended to provide information about how Iowa's water bodies are classified and what the use designations mean, hopefully providing a better general understanding for the reader.

All public surface waters in the state are protected for certain beneficial uses, such as livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and other incidental uses (e.g. withdrawal for industry and agriculture). However, certain rivers and lakes warrant a greater degree of protection because they provide enhanced recreational, economical, or ecological opportunities. Thus, all public bodies of surface water in Iowa are divided into two main categories: general use segments and designated use segments. This is an important classification because it means that not all of the criteria in the state's water quality standards apply to all water ways; rather, the criteria which apply depend on the use designation & classification of the water body.

General Use Segments

A general use segment water body is one which does not maintain perennial (year-round) flow of water or pools of water in most years (i.e. ephemeral or intermittent waterways). In other words, stream channels or basins which consistently dry up year after year would be classified as general use segments. Exceptions are made for years of extreme drought or floods. For the full definition of a general use water body, consult section 61.3(1) in the state's published water quality standards.

General use waters are protected for the beneficial uses listed above, which are: livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses. The criteria used to ensure protection of these uses are described in section 61.3(2) in the state's published water quality standards.

Designated Use Segments

Designated use segments are water bodies which maintain flow throughout the year, or at least hold pools of water which are sufficient to support a viable aquatic community (i.e. perennial waterways). In addition to being protected for the same beneficial uses as the general use segments, these perennial waters are protected for more specific activities such as primary contact recreation, drinking water sources, or cold-water fisheries. There are a total of thirteen different designated use classes (Table B.1) which may apply, and a water body may have more than one designated use. For definitions of the use classes and more detailed descriptions, consult section 61.3(1) in the state's published water quality standards

Table B.1. Designated use classes for Iowa water bodies.

Class prefix	Class	Designated use	Brief comments
A	A1	Primary contact recreation	Supports swimming, water skiing, etc.
	A2	Secondary contact recreation	Limited/incidental contact occurs, such as boating
	A3	Children's contact recreation	Urban/residential waters that are attractive to children
B	B(CW1)	Cold water aquatic life - Type 2	Able to support coldwater fish (e.g. trout) populations
	B(CW2)	Cold water aquatic life - Type 2	Typically unable to support consistent trout populations
	B(WW-1)	Warm water aquatic life - Type 1	Suitable for game and nongame fish populations
	B(WW-2)	Warm water aquatic life - Type 2	Smaller streams where game fish populations are limited by physical conditions & flow
	B(WW-3)	Warm water aquatic life - Type 3	Streams that only hold small perennial pools which extremely limit aquatic life
	B(LW)	Warm water aquatic life - Lakes and Wetlands	Artificial and natural impoundments with "lake-like" conditions
C	C	Drinking water supply	Used for raw potable water
Other	HQ	High quality water	Waters with exceptional water quality
	HQR	High quality resource	Waters with unique or outstanding features
	HH	Human health	Fish are routinely harvested for human consumption

Appendix C - Waste Load Allocation Calculations

Appendix C.1. Wasteload Allocation by Stream Segment for the Upper Chariton Watershed

This appendix provides description of the type of wasteload allocations (WLA) for facilities in all three HUC-10 watersheds in the study area. Included are tables of waste load allocations by segment and by facility type.

- AL - Aerated Lagoon
- AS - Activated Sludge
- AS/SBR- Activated Sludge/Sequencing Batch Reactor
- CAFO - Concentrated Animal Feeding Operation.
- GP #4 - Private Facility operating under an NPDES General Permit #4
- ST/SF - Septic Tank Sand Filter
- SW - Stormwater
- TF - Trickling Filter
- UNSWD - Unsewered Community
- WSL - Waste Stabilization Lagoon (Controlled Discharge Lagoon, CDL)

Wastewater Treatment Facility (WWTF)
WWTF can be grouped two types of discharging facilities, continuous and intermittent. All of the WWTF listed in this WQIP are continuous discharging facilities with the exception of Waste Stabilization Lagoons, which are intermittent discharging facilities.

The design flow for WWTF is the NPDES permitted average wet weather (AWW) flow. For a continuous discharging facility this is the 30-day AWW flow and the 180-day AWW flow for intermittent discharging facilities.

The WLA for continuous discharging facilities is the product of the WQS concentration of 126 orgs/100 ml and the design flow.

Intermittent discharging facilities operate as a hold and discharge facility with a minimum holding time of 180-days. These facilities typically discharge twice per year for short periods of time in the spring and in the fall when stream flows are at the highest. These facilities are permitted to discharge at a rate that is ten times the 180-day AWW flow. WLA for intermittent discharging facilities is the WQS concentration multiplied by ten times the 180-day AWW flow.

Unsewered (UNSWD)
WLA for unsewered communities is the product of the population and a per capita rate of 100 gallons per capita-day. Populations for unsewered communities were obtained or estimated from the 2010 US Census (U.S. Census Bureau, 2010). The per capita flow rate of 100 gallons per capita-day is required for facility planning of new WWTP by the Iowa Wastewater Facilities Design Standards. Unsewered communities with estimated populations of zero were omitted from WLA calculations.

Concentrated Animal Feeding Operations (CAFOs)
Regulatory CAFOs are not allowed to discharge, therefore their WLA is zero.

General Permit No. 4 (GP#4)
Facilities operating under a GP #4 are private systems that only treat domestic waste from commercial and residential properties and serve an equivalent population of less than 16 people. These sources are small and do not significantly contribute to the impairment. Therefore, a WLA for these systems is not included in this WQIP.

Stormwater (SW)

NPDES permits for MS4 communities do not include numeric limits for *E. coli*. However, they do include storm water pollution prevention and management provisions that include the implementation of Best Management Practices (BMP) to reduce pollutants in the discharge.

The WLA for MS4 communities in this WQIP are based on the ratio of the area of the MS4 community to the drainage area attributed to the impaired segment that the community discharges to multiply by the TMDL attributed to the drainage area of that impaired segment. There are no MS4 communities in the Upper Chariton River Watershed.

The various point sources in each impaired segment of the Upper Chariton River Watershed will be organized by HUC 10.

Point Sources in Wolf Creek – Chariton River HUC 10 impaired segments

Table C.1. WLA for IA 05-CHA-1310

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
Alexander David & Ewing Family Farms Lc	CAFO	58437	0.00E+00	126	0.00E+00
Wayne Finisher Farm	CAFO	69152	0.00E+00	126	0.00E+00
1 Permitted Facility	GP #4	--	0.00E+00	126	0.00E+00
Totals	--	--	0.00E+00	126	0.00E+00

Table C.2. WLA for IA 05-CHA-1311

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
DERBY CITY OF STP	WSL	5909001	1.35E+04	126	6.44E+08
Derby Sow Farm S034	CAFO	69194	0.00E+00	126	0.00E+00
2 Permitted Facilities	GP #4	--	--	126	0.00E+00
Totals	--	--	1.35E+04	126	6.44E+08

Table C.3. WLA for IA 05-CHA-1312

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
HUMESTON CITY OF STP	AL	9348001	2.70E+05	126	1.28E+09
Last Chance Sow Farm	CAFO	60069	0.00E+00	126	0.00E+00
Smyrna Sow Farm	CAFO	69833	0.00E+00	126	0.00E+00
Le Roy	UNSWD	--	1.40E+03	126	6.68E+06
1 Permitted Facility	GP #4	--	--	126	0.00E+00
Totals	--	--	2.71E+05	126	1.28E+09

Table C.4. WLA for IA 05-CHA-1313

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
Iowa Quality Farms Lc	CAFO	59925	0.00E+00	126	0.00E+00
Weldon	UNSWD	--	1.20E+04	126	5.72E+07
Totals	--	--	1.20E+04	126	5.72E+07

Table C.5. WLA for IA 05-CHA-1337

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
RUSSEL CITY OF STP	AL	5939001	3.10E+05	126	1.48E+09
1 Permitted Facility	GP #4	--	0.00E+00	126	0.00E+00
Totals	--	--	3.10E+05	126	1.48E+09

Table C.6. WLA for IA 05-CHA-1339

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
2 Permitted Facilities	GP #4	--	0.00E+00	126	0.00E+00
Totals	--	--	0.00E+00	126	0.00E+00

Table C.7. WLA for IA 05-CHA-1341

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
Lucas Gilt Developer Unit	CAFO	60671	0.00E+00	126	0.00E+00
Totals	--	--	0.00E+00	126	0.00E+00

Point Sources in South Fork Chariton River HUC 10 impaired segments

Table C.8. WLA for IA 05-CHA-1329

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
Confidence	UNSWD	--	1.60E+03	126	7.63E+06
Paul Alexander Farms	CAFO	62619	0.00E+00	126	0.00E+00
Double A Pork Inc	CAFO	63942	0.00E+00	126	0.00E+00
Totals	--	--	1.63E+03	126	0.00E+00

Table C.9. WLA for IA 05-CHA-1330

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
Millerton	UNSWD	--	4.80E+03	126	2.29E+07
Totals	--	--	4.80E+03	126	2.29E+07

Table C.10. WLA for IA 05-CHA-1332

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
ALLERTON CITY OF STP	AL	9303003	2.10E+05	126	1.00E+09
CORYDON CITY OF STP	AL	9334004	9.36E+05	126	4.46E+09
Totals	--	--	1.15E+06	126	5.47E+09

Table C.11. WLA for IA 05-CHA-1335

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
Cambria	UNSWD	--	4.40E+03	126	2.10E+07
Totals	--	--	4.40E+03	126	2.10E+07

Point Sources in Cooper Creek – Chariton River HUC 10 impaired segments

Table C.12. WLA for IA 05-CHA-1308

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
Iowa DNR Rathbun Fish Hatchery	WSL	400913	8.00E+03	126	3.82E+07
Rathbun Regional Water Association	OTHER	400918	3.80E+04	126	1.81E+08
Centerville City of STP (east)	AS	407003	1.50E+06	126	7.15E+09
Centerville City of STP (west)	AS	407004	4.10E+05	126	1.96E+09
Mystic City of Stp	WSL	477001	7.10E+04	126	3.39E+08
Plano, Iowa	WSL	484001	6.00E+03	126	2.86E+07
Promise City, City of Stp	WSL	9360001	1.30E+04	126	6.20E+07
Seymour City of Stp	WSL	9368001	1.10E+05	126	5.25E+08
Promise City	UNSWD	--	1.12E+04	126	5.34E+07
Darbyville	UNSWD	--	3.00E+03	126	1.43E+07
Rathbun	UNSWD	--	8.80E+03	126	4.20E+07
Jerome	UNSWD	--	3.40E+03	126	1.62E+07
Plano	UNSWD	--	6.90E+03	126	3.29E+07
Numa	UNSWD	--	9.10E+03	126	4.34E+07
3 Permitted Facilities	GP#4	--	--	126	0.00E+00
Totals	--	--	2.20E+06	126	1.05E+10

Appendix C.2. WLA by Treatment Type

This appendix provides the WLA for each facility based on the Treatment Type. Treatment types include: Municipal and Semi-public (WWTF); CAFO; General Permit #4; Unsewered; and Stormwater.

Wastewater Treatment Facility (WWTF) includes the following facility types:

- AL - Aerated Lagoon
- AS - Activated Sludge
- AS/SBR- Activated Sludge/Sequencing Batch Reactor
- ST/SF - Septic Tank Sand Filter
- TF - Trickling Filter
- WSL - Waste Stabilization Lagoon

Table C.13. WLA for WWTFs in Upper Chariton River Watershed

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day[1]
ALLERTON CITY OF STP	AL	9303003	2.10E+05	126	1.00E+09
CORYDON CITY OF STP	AL	9334004	9.36E+05	126	4.46E+09
HUMESTON CITY OF STP	AL	9348001	2.70E+05	126	1.28E+09
RUSSEL CITY OF STP	AL	5939001	3.10E+05	126	1.48E+09
Centerville City of STP (east)	AS	407003	1.50E+06	126	7.15E+09
Centerville City of STP (west)	AS	407004	4.10E+05	126	1.96E+09
Promise City, City of Stp[2]	WSL	9360001	1.30E+04	126	6.20E+07
Seymour City of Stp[2]	WSL	9368001	1.10E+05	126	5.25E+08

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day[1]
Iowa DNR Rathbun Fish Hatchery[2]	WSL	400913	8.00E+03	126	3.82E+07
Plano, Iowa[2]	WSL	484001	6.00E+03	126	2.86E+07
Mystic City of Stp[2]	WSL	477001	7.10E+04	126	3.39E+08
DERBY CITY OF STP[2]	WSL	5909001	1.35E+04	126	6.44E+08
Rathbun Regional Water Association	OTHER	400918	3.80E+04	126	1.81E+08
Totals	--	--	3.90E+06	126	1.91E+10

[1]The WLA for continuous discharging facilities is the product of the WQS concentration of 126 orgs/100 ml and the design flow.
[2]The WLA for intermittent discharging facilities is the WQS concentration multiplied by ten times the 180-day AWW flow.

Table C.14. WLA for CAFOs in Upper Chariton River Watershed

Facility Name	Facility Type	Iowa NPDES ID or AFO ID	Design Flow (gpd)	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day[1]
Iowa Quality Farms Lc	CAFO	59925	0.0	126	0.00E+00
Last Chance Sow Farm	CAFO	60069	0.0	126	0.00E+00
Derby Sow Farm S034	CAFO	69194	0.0	126	0.00E+00
Lucas Gilt Developer Unit	CAFO	60671	0.0	126	0.00E+00
Alexander David & Ewing Family Farms Lc	CAFO	58437	0.0	126	0.00E+00
Smyrna Sow Farm	CAFO	69833	0.0	126	0.00E+00
Wayne Finisher Farm	CAFO	69152	0.0	126	0.00E+00
Paul Alexander Farms	CAFO	62619	0.0	126	0.00E+00
Double A Pork Inc	CAFO	63942	0.0	126	0.00E+00
Totals	--	--	0.0	126	0.00E+00

[1]Regulatory CAFOs are not allowed to discharge therefore their WLA is zero.

Table C.15. Estimated Wasteloads for GP #4 in Upper Chariton River Watershed

Facility Name	Facility Type	Design Flow (gpd)	Stream Segment	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day
1 Permitted Facilities	GP #4	--	IA 05-CHA-1310	126	--
2 Permitted Facilities	GP #4	--	IA 05-CHA-1311	126	--
1 Permitted Facility	GP #4	--	IA 05-CHA-1313	126	--
1 Permitted Facilities	GP #4	--	IA 05-CHA-1337	126	--
2 Permitted Facilities	GP #4	--	IA 05-CHA-1339	126	--
3 Permitted Facilities	GP #4	--	IA 05-CHA-1308	126	--
Totals		--		126	--

[1]These sources are small and do not significantly contribute to the impairment. Therefore, a WLA for these systems is not included in this WQIP.

Table C.16. Unsewered communities in Upper Chariton River Watershed

Facility Name	Facility Type	Population[1]	Design Flow (gpd)	Receiving Stream Segment	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day[1]
Le Roy	UNSWD	14	1.40E+03	IA 05-CHA-1312	126	6.68E+06
Weldon	UNSWD	120	1.20E+04	IA 05-CHA-1313	126	5.72E+07
Confidence	UNSWD	16	1.60E+03	IA 05-CHA-1329	126	7.63E+06
Millerton	UNSWD	48	4.80E+03	IA 05-CHA-1330	126	2.29E+07
Cambria	UNSWD	44	4.40E+02	IA 05-CHA-1335	126	2.10E+07

Facility Name	Facility Type	Population[1]	Design Flow (gpd)	Receiving Stream Segment	GM, *E. coli*, orgs/100 mL	WLA, *E. coli*, orgs/day[1]
Promise City	UNSWD	112	1.12E+04	IA 05-CHA-1308	126	5.34E+07
Darbyville	UNSWD	30	3.00E+03	IA 05-CHA-1308	126	1.43E+07
Rathbun	UNSWD	88	8.80E+03	IA 05-CHA-1308	126	4.20E+07
Jerome	UNSWD	34	3.40E+03	IA 05-CHA-1308	126	1.62E+07
Plano	UNSWD	69	6.90E+03	IA 05-CHA-1308	126	3.29E+07
Numa	UNSWD	91	9.10E+03	IA 05-CHA-1308	126	4.34E+07
Totals		663	6.26E+04		126	3.18E+08

[1]WLA for unsewered communities is the product of the population and a per capita rate of 100 gallons per capita-day times the WQS concentration.

Appendix C.3. Water Quality Data

Water Quality Data in Wolf Creek – Chariton River HUC 10 impaired segments

Table C.17. Water Quality Data for IA-CHA-1310

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	1.048	10	5/25/2006	67.341	344.8
4/18/2000	1.603	10	6/7/2006	2.294	196.8
5/16/2000	1.973	110	6/21/2006	0.308	1011.2
6/13/2000	123.335	190	7/27/2006	0.506	913.9
6/27/2000	838.679	2100	8/28/2006	2.331	478.6
7/19/2000	17.267	1300	9/13/2006	1.172	275.5
8/15/2000	8.633	63	10/12/2006	0.012	82
9/12/2000	0.925	930	5/29/2008	46.867	325.5
10/17/2000	0.691	86	6/3/2008	608.042	1413.6
11/14/2000	1.603	20	6/16/2008	820.179	206.4
3/20/2001	709.177	310	7/1/2008	51.061	344.8
4/17/2001	168.969	910	7/15/2008	18.130	139.6
5/15/2001	1591.023	1400	8/12/2008	34.287	228.2
6/1/2001	2812.041	1600	9/8/2008	12.223	1413.6
6/12/2001	50.567	100	10/27/2008	144.302	920.8
7/11/2001	10.607	110	11/4/2008	35.891	193.5
8/14/2001	0.592	130	5/14/2009	67.711	122.3
9/27/2001	1.184	1200	5/28/2009	479.774	2419.6
10/16/2001	6.290	74	6/18/2009	58.338	2419.6
11/13/2001	4.563	10	6/25/2009	252.837	344.8
3/26/2002	20.967	10	7/16/2009	50.444	547.5
4/16/2002	37.001	40	8/11/2009	275.037	2419.6
5/14/2002	1418.354	1300	8/17/2009	1202.518	2419.6
6/11/2002	39.467	2900	9/23/2009	9.398	325.5
7/23/2002	1.973	300	10/27/2009	149.236	727.0
8/13/2002	0.555	230	3/22/2010	482.240	122.3
9/17/2002	0.333	350	4/19/2010	43.907	37.7
10/24/2002	0.123	110	4/24/2010	1911.695	2419.6
11/12/2002	0.234	30	5/11/2010	2516.037	2419.6
4/15/2003	4.563	10	5/26/2010	217.070	1986.3
5/14/2003	24.667	260	6/22/2010	1541.689	2419.6
6/17/2003	6.290	340	7/13/2010	74.124	235.9
7/15/2003	1.357	40	8/11/2010	442.773	2419.6
7/29/2003	0.321	400	9/21/2010	1282.685	2419.6
8/12/2003	0.049	160	10/9/2010	18.870	344.8
9/16/2003	6.228	360	8/16/2011	11.791	800.0
10/16/2003	0.543	30	9/19/2011	1.061	560.0
3/31/2004	131.969	750	10/17/2011	0.173	20.0
4/21/2004	37.001	760	4/16/2012	1233.351	20000.0

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
5/19/2004	19.734	270	5/3/2012	2109.031	17000.0
6/22/2004	40.701	200	6/18/2012	205.970	6500.0
9/21/2004	5.303	320	6/26/2012	81.525	560.0
10/19/2004	6.722	10	7/11/2012	0.099	52.0
3/16/2005	17.267	10	10/22/2012	4.033	130.0
4/13/2005	2010.363	3100			
5/10/2005	15.047	80			
6/15/2005	73.261	1652			
6/29/2005	67.341	3840	Min =	0.012	10
7/20/2005	0.913	288	1st Quartile =	2.0	110
7/28/2005	3.046	727	Median =	18.1	326
8/25/2005	0.802	291	3rd Quartile =	144.3	1200
3/16/2006	2.183	21.1	Max =	2812	20000
4/12/2006	2.812	77.1	Mean(1) =	270	1171
4/27/2006	1.381	72.4	Std Dev =	580	2748

[1]For *E. coli* this is a geomean

Table C.18. Water Quality Data for IA-CHA-1311

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	0.733	10	8/25/2005	0.619	291
4/18/2000	0.989	10	3/16/2006	1.256	21.1
5/16/2000	1.159	110	4/12/2006	1.546	77.1
6/13/2000	57.087	190	4/27/2006	0.887	72.4
6/27/2000	386.744	2100	5/25/2006	31.283	344.8
7/19/2000	8.207	1300	6/7/2006	1.307	196.8
8/15/2000	4.229	63	6/21/2006	0.392	1011.2
9/12/2000	0.676	930	7/27/2006	0.483	913.9
10/17/2000	0.568	86	8/28/2006	1.324	478.6
11/14/2000	0.989	20	9/13/2006	0.790	275.5
3/20/2001	327.064	310	10/12/2006	0.256	82
4/17/2001	78.117	910	5/29/2008	21.848	325.5
5/15/2001	733.451	1400	6/3/2008	280.458	1413.6
6/1/2001	1296.140	1600	6/16/2008	378.218	206.4
6/12/2001	23.553	100	7/1/2008	23.781	344.8
7/11/2001	5.138	110	7/15/2008	8.605	139.6
8/14/2001	0.523	130	8/12/2008	16.051	228.2
9/27/2001	0.796	1200	9/8/2008	5.883	1413.6
10/16/2001	3.149	74	10/27/2008	66.750	920.8
11/13/2001	2.353	10	11/4/2008	16.790	193.5
3/26/2002	9.912	10	5/14/2009	31.454	122.3
4/16/2002	17.301	40	5/28/2009	221.347	2419.6
5/14/2002	653.879	1300	6/18/2009	27.134	2419.6

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
6/11/2002	18.438	2900	6/25/2009	116.766	344.8
7/23/2002	1.159	300	7/16/2009	23.496	547.5
8/13/2002	0.506	230	8/11/2009	126.997	2419.6
9/17/2002	0.403	350	8/17/2009	554.414	2419.6
10/24/2002	0.307	110	9/23/2009	4.581	325.5
11/12/2002	0.358	30	10/27/2009	69.023	727.0
4/15/2003	2.353	10	3/22/2010	222.484	122.3
5/14/2003	11.617	260	4/19/2010	20.484	37.7
6/17/2003	3.149	340	4/24/2010	881.228	2419.6
7/15/2003	0.875	40	5/11/2010	1159.731	2419.6
7/29/2003	0.398	400	5/26/2010	100.284	1986.3
8/12/2003	0.273	160	6/22/2010	710.716	2419.6
9/16/2003	3.120	360	7/13/2010	34.409	235.9
10/16/2003	0.500	30	8/11/2010	204.296	2419.6
3/31/2004	61.066	750	9/21/2010	591.358	2419.6
4/21/2004	17.301	760	10/9/2010	8.946	344.8
5/19/2004	9.344	270	8/16/2011	5.684	800.0
6/22/2004	19.006	200	9/19/2011	0.739	560.0
7/13/2004	148.595	7000	10/17/2011	0.330	20.0
7/20/2004	2.921	360	4/16/2012	568.623	20000.0
8/17/2004	2.751	180	5/3/2012	972.168	17000.0
9/21/2004	2.694	320	6/18/2012	95.168	6500.0
10/19/2004	3.348	10	6/26/2012	37.819	560.0
3/16/2005	8.207	10	7/11/2012	0.295	52.0
4/13/2005	926.698	3100	10/22/2012	2.109	130.0
5/10/2005	7.184	80	Min =	0.26	10
6/15/2005	34.011	1652	1st Quartile =	1.2	110
6/29/2005	31.283	3840	Median =	8.6	326
7/20/2005	0.671	288	3rd Quartile =	66.7	1200
7/28/2005	1.654	727	Max =	1296	20000
			Mean(1) =	125	1171
			Std Dev =	267	2748

1For *E. coli* this is a geomean

Table C.19. Water Quality Data for IA-CHA-1312

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	0.662	230	5/25/2006	10.827	2419.6
4/18/2000	0.747	41	6/7/2006	0.853	201.4
5/16/2000	0.804	10	8/28/2006	0.858	2420
6/13/2000	19.413	52	5/29/2008	7.687	547.5
6/27/2000	129.100	260	6/3/2008	93.735	2419.6
7/19/2000	3.149	1300	6/16/2008	126.263	272.3

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
8/15/2000	1.825	170	7/1/2008	8.330	461.1
9/12/2000	0.643	30	7/15/2008	3.281	178.5
3/20/2001	109.243	270	8/12/2008	5.758	193.5
4/17/2001	26.410	390	9/8/2008	2.375	130.1
5/15/2001	244.461	880	10/27/2008	22.628	980.4
6/1/2001	431.686	2100	11/4/2008	6.004	60.5
6/12/2001	8.255	100	5/14/2009	10.883	2419.6
7/11/2001	2.127	160	5/28/2009	74.067	1299.7
8/14/2001	0.592	41	6/18/2009	9.446	547.5
9/27/2001	0.683	180	6/25/2009	39.270	461.1
10/16/2001	1.465	990	7/16/2009	8.236	1046.2
11/13/2001	1.201	63	8/11/2009	42.674	1119.9
3/26/2002	3.716	10	8/17/2009	184.889	1986.3
4/16/2002	6.174	130	9/23/2009	1.942	65.0
5/14/2002	217.985	660	10/27/2009	23.384	770.1
6/11/2002	6.553	5900	3/22/2010	74.446	816.4
7/23/2002	0.804	240	4/19/2010	7.234	110.6
4/15/2003	1.201	90	4/24/2010	293.631	2419.6
5/14/2003	4.283	170	5/11/2010	386.298	2419.6
6/17/2003	1.465	80	5/26/2010	33.785	2419.6
7/15/2003	0.709	220	6/22/2010	236.896	1119.9
7/29/2003	0.550	1400	7/13/2010	11.867	275.5
9/16/2003	1.456	300	8/11/2010	68.394	61.8
3/31/2004	20.736	570	9/21/2010	197.182	686.7
4/21/2004	6.174	4400	10/9/2010	3.394	290.9
5/19/2004	3.527	44000	8/15/2011	2.207	440.0
5/26/2004	99.409	2400	9/20/2011	0.637	580.0
6/22/2004	6.742	280	10/18/2011	0.527	200.0
7/13/2004	49.860	2800	6/27/2012	4.227	300.0
7/20/2004	1.390	910	7/12/2012	0.516	1300.0
8/17/2004	1.333	170	10/23/2012	1.150	130.0
9/21/2004	1.314	340			
3/16/2005	3.149	10			
4/13/2005	308.761	1400			
5/10/2005	2.808	50	Min =	0.52	10
6/15/2005	11.735	271	1st Quartile =	1.29	153
6/29/2005	10.827	406	Median =	5.9	300
7/28/2005	0.968	1250	3rd Quartile =	28.3	1120
3/16/2006	0.836	16	Max =	431.7	44000
4/12/2006	0.932	248.1	Mean(1) =	44.8	1305
4/27/2006	0.713	45.2	Std Dev =	89.6	4798

(1) For *E. coli* this is a geomean

Table C.20. Water Quality Data for IA-CHA-1313

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	0.092	41	4/12/2006	0.246	248.1
4/18/2000	0.140	10	5/25/2006	5.898	1732.9
5/16/2000	0.173	10	8/28/2006	0.204	2420
6/13/2000	10.803	41	9/13/2006	0.103	58.3
6/27/2000	73.459	500	5/29/2008	4.105	187.2
7/19/2000	1.512	320	6/3/2008	53.258	2419.6
8/15/2000	0.756	460	6/16/2008	71.839	261.3
11/14/2000	0.140	63	7/1/2008	4.472	224.7
3/20/2001	62.116	270	7/15/2008	1.588	517.2
4/17/2001	14.800	86	8/12/2008	3.003	129.1
5/15/2001	139.356	390	9/8/2008	1.071	2419.6
6/1/2001	246.304	1100	10/27/2008	12.639	98.5
6/12/2001	4.429	100	11/4/2008	3.144	16.1
7/11/2001	0.929	63	5/14/2009	5.931	209.8
8/14/2001	0.052	52	5/28/2009	42.023	1299.7
9/27/2001	0.104	41	6/18/2009	5.110	517.2
10/16/2001	0.551	20	6/25/2009	22.146	224.7
11/13/2001	0.400	20	7/16/2009	4.418	235.9
3/26/2002	1.836	10	8/11/2009	24.090	488.4
4/16/2002	3.241	10	8/17/2009	105.327	920.8
5/14/2002	124.232	600	9/23/2009	0.823	321.8
6/11/2002	3.457	460	10/27/2009	13.071	248.9
7/23/2002	0.173	500	3/22/2010	42.239	120.5
4/15/2003	0.400	6000	4/19/2010	3.846	201.4
5/14/2003	2.161	90	4/24/2010	167.443	2419.6
6/17/2003	0.551	640	5/11/2010	220.377	2419.6
7/15/2003	0.119	860	5/26/2010	19.013	325.5
7/29/2003	0.028	1400	6/22/2010	135.035	1203.3
9/16/2003	0.546	420	7/13/2010	6.492	275.5
4/21/2004	3.241	23000	8/11/2010	38.782	1986.3
5/19/2004	1.728	4100	9/21/2010	112.349	2419.6
5/26/2004	56.499	2000	10/9/2010	1.653	228.2
7/13/2004	28.195	3100	8/15/2011	0.974	280.0
8/17/2004	0.475	450	9/20/2011	0.078	110.0
9/21/2004	0.465	210	10/18/2011	0.015	210.0
10/19/2004	0.589	10	6/27/2012	2.128	240.0
3/16/2005	1.512	63	7/12/2012	0.009	410.0
4/13/2005	176.086	10	Min =	0.009	10
5/10/2005	1.318	580	1st Quartile =	0.46	100
6/15/2005	6.417	360	Median =	3.0	280
6/29/2005	5.898	478	3rd Quartile =	19	860
7/20/2005	0.080	238	Max =	246	23000
7/28/2005	0.267	1640	Mean[(1)] =	26	993
8/25/2005	0.070	1607	Std Dev =	52	2667

[1]For *E. coli* this is a geomean

Table C.21. Water Quality Data for IA-CHA-1337

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	0.661	20	6/15/2005	5.535	344
4/18/2000	0.698	10	6/29/2005	5.135	738
6/13/2000	8.914	1200	7/28/2005	0.796	2142
6/27/2000	57.196	790	4/12/2006	0.780	28.8
7/19/2000	1.755	200	4/27/2006	0.683	25.6
8/15/2000	1.173	180	5/25/2006	5.135	517.2
10/17/2000	0.637	610	6/7/2006	0.745	920.8
11/14/2000	0.698	1800	5/29/2008	3.753	1413.6
3/20/2001	48.455	140	6/3/2008	41.629	1553.1
4/17/2001	11.994	190	6/16/2008	55.947	1732.9
5/15/2001	107.974	270	7/1/2008	4.036	980.4
6/1/2001	190.385	1400	7/15/2008	1.814	488.4
6/12/2001	4.003	100	8/12/2008	2.904	30.1
8/14/2001	0.630	160	5/14/2009	5.160	2419.6
9/27/2001	0.670	140	5/28/2009	32.972	2419.6
10/16/2001	1.015	210	6/18/2009	4.527	686.7
11/13/2001	0.898	31	6/25/2009	17.655	980.4
3/26/2002	2.005	10	7/16/2009	3.995	2419.6
4/16/2002	3.087	27	8/11/2009	19.153	841.4
5/14/2002	96.320	200	8/17/2009	81.752	2419.6
6/11/2002	3.254	910	9/23/2009	1.224	2419.6
4/15/2003	0.898	10	10/27/2009	10.662	727.0
5/14/2003	2.255	72	3/22/2010	33.138	135.4
6/17/2003	1.015	600	4/19/2010	3.553	117.8
7/15/2003	0.682	2000	4/24/2010	129.617	2419.6
7/29/2003	0.612	1100	5/11/2010	170.407	2419.6
3/31/2004	9.497	40	5/26/2010	15.241	461.1
4/21/2004	3.087	690	8/16/2011	1.386	10000.0
5/19/2004	1.922	950	9/19/2011	0.662	260.0
5/26/2004	44.126	3400	10/17/2011	0.602	86.0
6/22/2004	3.337	590	6/26/2012	6.092	2600.0
7/13/2004	22.317	12000	7/11/2012	0.597	2300.0
7/20/2004	0.981	800	Min =	0.597	10
8/17/2004	0.956	490	1st Quartile =	0.95	140
9/21/2004	0.948	330	Median =	3.1	590
10/19/2004	1.044	330	3rd Quartile =	14	1407
3/16/2005	1.755	20	Max =	190	12000
4/13/2005	136.277	360	Mean(1) =	20	1120
5/10/2005	1.606	90	Std Dev =	40	1895

1For *E. coli* this is a geomean

Table C.22. Water Quality Data for IA-CHA-1339

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	0.305	10	4/12/2006	0.818	5.2
4/18/2000	0.466	10	5/25/2006	19.586	2420
5/16/2000	0.574	31	6/7/2006	0.667	2419.6
6/13/2000	35.872	86	6/21/2006	0.090	1011.2
6/27/2000	243.931	1100	5/29/2008	13.631	150
7/19/2000	5.022	380	6/3/2008	176.850	1986.3
8/15/2000	2.511	86	6/16/2008	238.550	387.3
9/12/2000	0.269	170	7/1/2008	14.851	686.7
10/17/2000	0.201	290	7/15/2008	5.273	313
11/14/2000	0.466	97	8/12/2008	9.972	157.6
3/20/2001	206.265	230	9/8/2008	3.555	167
4/17/2001	49.145	500	10/27/2008	41.970	686.7
5/15/2001	462.751	1200	11/4/2008	10.439	24.3
6/1/2001	817.885	3800	5/14/2009	19.694	365.4
6/12/2001	14.708	100	5/28/2009	139.543	1299.7
7/11/2001	3.085	380	6/18/2009	16.968	1046.2
8/14/2001	0.172	200	6/25/2009	73.538	686.7
9/27/2001	0.344	280	7/16/2009	14.672	866.4
10/16/2001	1.829	250	8/11/2009	79.995	2419.6
11/13/2001	1.327	41	8/17/2009	349.754	2419.6
3/26/2002	6.098	20	9/23/2009	2.733	579.4
4/16/2002	10.762	270	10/27/2009	43.405	1119.9
5/14/2002	412.530	1500	3/22/2010	140.260	727.0
6/11/2002	11.479	1000	4/19/2010	12.770	63.8
7/23/2002	0.574	1200	4/24/2010	556.018	2419.6
8/13/2002	0.161	1100	5/11/2010	731.792	2419.6
4/15/2003	1.327	20	5/26/2010	63.135	2419.6
5/14/2003	7.174	110	6/22/2010	448.402	2419.6
6/17/2003	1.829	940	7/13/2010	21.559	365.4
7/15/2003	0.395	490	8/11/2010	128.781	2419.6
7/29/2003	0.093	1300	9/21/2010	373.070	2419.6
8/12/2003	0.014	1500	10/9/2010	5.488	193.1
9/16/2003	1.812	510	8/16/2011	3.429	1500.0
3/31/2004	38.383	210	9/19/2011	0.309	210.0
4/21/2004	10.762	600	10/17/2011	0.050	20.0
5/19/2004	5.740	230	4/14/2012	40.177	6900.0
5/26/2004	187.611	4000	5/3/2012	613.414	16000.0
6/22/2004	11.838	460	6/18/2012	59.907	8200.0
7/13/2004	93.626	5700	6/26/2012	23.711	790.0
7/20/2004	1.686	830	7/12/2012	0.029	720.0
8/17/2004	1.578	650	10/22/2012	1.173	440.0

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
9/21/2004	1.543	210			
10/19/2004	1.955	10	Min =	0.014	5
3/16/2005	5.022	30	1st Quartile =	1.33	182
4/13/2005	584.716	1800	Median =	10	579
5/10/2005	4.376	50	3rd Quartile =	55	1300
6/15/2005	21.308	1298	Max =	818	16000
6/29/2005	19.586	1780	Mean(1) =	86	1204
7/28/2005	0.886	602	Std Dev =	173	5
3/16/2006	0.635	26.2	[1]or *E. coli* this is a geomean		

Table C.23. Water Quality Data for IA-CHA-1341

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	0.062	20	8/28/2006	0.138	2420
4/18/2000	0.095	260	5/29/2008	2.770	579.4
5/16/2000	0.117	430	6/3/2008	35.939	2419.6
6/13/2000	7.290	10	6/16/2008	48.478	488.4
6/27/2000	49.571	1000	7/1/2008	3.018	461.1
7/19/2000	1.021	120	7/15/2008	1.072	488.4
11/14/2000	0.095	270	8/12/2008	2.027	178.2
3/20/2001	41.917	880	9/8/2008	0.722	1732.9
4/17/2001	9.987	470	10/27/2008	8.529	1046.2
5/15/2001	94.039	4900	5/14/2009	4.002	1203.3
6/1/2001	166.209	5000	5/28/2009	28.358	2419.6
6/12/2001	2.989	410	6/18/2009	3.448	866.4
7/11/2001	0.627	400	6/25/2009	14.944	461.1
8/14/2001	0.035	220	7/16/2009	2.982	2419.6
9/27/2001	0.070	110	8/11/2009	16.256	2419.6
10/16/2001	0.372	1500	8/17/2009	71.076	2419.6
11/13/2001	0.270	1300	9/23/2009	0.555	275.5
3/26/2002	1.239	10	10/27/2009	8.821	1046.2
4/16/2002	2.187	500	3/22/2010	28.503	172.2
5/14/2002	83.834	2000	4/19/2010	2.595	579.4
6/11/2002	2.333	1900	4/24/2010	112.993	2419.6
4/15/2003	0.270	81	5/11/2010	148.713	2419.6
5/14/2003	1.458	520	5/26/2010	12.830	866.4
6/17/2003	0.372	80	6/22/2010	91.123	2419.6
7/15/2003	0.080	530	7/13/2010	4.381	1119.9
7/29/2003	0.019	190	8/11/2010	26.171	2419.6
9/16/2003	0.368	1400	9/21/2010	75.815	1299.7
4/21/2004	2.187	670	10/9/2010	1.115	1986.3
5/19/2004	1.166	2300	8/15/2011	0.658	620.0
5/26/2004	38.126	4100	9/20/2011	0.052	750.0

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
6/15/2004	142.152	4500	10/18/2011	0.010	10.0
6/22/2004	2.406	600	6/27/2012	1.436	460.0
7/13/2004	19.027	5600	7/12/2012	0.006	41.0
3/16/2005	1.021	20	Min =	0.006	10
4/13/2005	118.825	1900	1st Quartile =	0.56	410
5/10/2005	0.889	530	Median =	2.6	750
6/15/2005	4.330	4060	3rd Quartile =	19	2300
6/29/2005	3.980	5310	Max =	166	5600
4/12/2006	0.166	613.1	Mean(1) =	21	1343
5/25/2006	3.980	2420	Std Dev =	39	1386

1For *E. coli* this is a geomean

Table C.24. Water Quality Data for IA-CHA-2019

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	0.034	1300	5/29/2008	1.527	344.8
4/18/2000	0.052	20	6/3/2008	19.816	2419.6
5/16/2000	0.064	10	6/16/2008	26.729	365.4
6/13/2000	4.019	61	7/1/2008	1.664	285.1
6/27/2000	27.332	550	7/15/2008	0.591	920.8
7/19/2000	0.563	4400	8/12/2008	1.117	1986.3
8/15/2000	0.281	1200	9/8/2008	0.398	2419.6
10/17/2000	0.023	10	10/27/2008	4.703	298.7
11/14/2000	0.052	10	11/4/2008	1.170	10.8
3/20/2001	23.112	160	5/14/2009	2.207	2419.6
4/17/2001	5.507	200	5/28/2009	15.635	2419.6
5/15/2001	51.850	170	6/18/2009	1.901	436.0
6/1/2001	91.642	440	6/25/2009	8.240	285.1
6/12/2001	1.648	520	7/16/2009	1.644	1203.3
7/11/2001	0.346	680	8/11/2009	8.963	920.8
8/14/2001	0.019	74	8/17/2009	39.189	2419.6
9/27/2001	0.039	460	9/23/2009	0.306	816.4
10/16/2001	0.205	98	10/27/2009	4.863	387.3
11/13/2001	0.149	150	3/22/2010	15.716	21.3
3/26/2002	0.683	10	4/19/2010	1.431	135.4
4/16/2002	1.206	10	4/24/2010	62.301	2419.6
5/14/2002	46.223	420	5/11/2010	81.996	980.4
6/11/2002	1.286	3100	5/26/2010	7.074	290.9
4/15/2003	0.149	10	6/22/2010	50.242	1203.3
5/14/2003	0.804	72	7/13/2010	2.416	686.7
6/17/2003	0.205	260	8/11/2010	14.430	2419.6
7/15/2003	0.044	1400	9/21/2010	41.802	579.4
7/29/2003	0.010	550	8/16/2011	0.384	2900.0

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/31/2004	4.301	130	9/19/2011	0.035	180.0
5/26/2004	21.021	950	10/17/2011	0.006	370.0
6/15/2004	78.378	2100	6/26/2012	2.657	440.0
6/22/2004	1.326	880	7/11/2012	0.003	34000.0
7/13/2004	10.491	930			
7/20/2004	0.189	1400	Min =	0.003	10
9/21/2004	0.173	80	1st Quartile =	0.20	122
3/16/2005	0.563	40	Median =	1.4	428
4/13/2005	65.516	230	3rd Quartile =	11.5	1201
5/10/2005	0.490	40	Max =	91.6	34000
4/12/2006	0.092	57.6	Mean(1) =	12.0	1253
4/27/2006	0.045	33.7	Std Dev =	21.7	3996

[1]For *E. coli* this is a geomean

Water Quality Data in South Fork Chariton River HUC 10 impaired segments

Table C.25. Water Quality Data for IA-CHA-1327

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	1.045	41	3/16/2006	2.175	27.5
4/18/2000	1.598	10	4/12/2006	2.802	62.4
5/16/2000	1.966	10	4/27/2006	1.376	64
6/13/2000	122.891	360	5/25/2006	67.098	2420
6/27/2000	835.658	930	6/7/2006	2.286	238.2
7/19/2000	17.205	930	6/21/2006	0.307	119.1
8/15/2000	8.602	390	7/27/2006	0.504	330
9/12/2000	0.922	85	8/28/2006	2.323	1986.3
10/17/2000	0.688	86	9/13/2006	1.167	410.6
11/14/2000	1.598	850	10/12/2006	0.012	93.3
3/20/2001	706.622	610	11/9/2006	1.032	68.3
4/17/2001	168.360	290	5/29/2008	46.699	387.3
5/15/2001	1585.292	6900	6/3/2008	605.852	1986.3
6/1/2001	2801.912	3800	6/16/2008	817.224	2419.6
6/12/2001	50.385	100	7/1/2008	50.877	172.6
7/11/2001	10.569	300	7/15/2008	18.065	290.9
8/14/2001	0.590	990	8/12/2008	34.164	34.5
9/27/2001	1.180	1700	9/8/2008	12.178	272.3
10/16/2001	6.267	280	10/27/2008	143.782	920.8
11/13/2001	4.547	140	11/4/2008	35.761	41.4
3/26/2002	20.891	10	5/14/2009	67.467	2419.6
4/16/2002	36.867	10	5/28/2009	478.045	2419.6
5/14/2002	1413.245	840	6/18/2009	58.127	146.7
6/11/2002	39.325	1300	6/25/2009	251.926	172.6
7/23/2002	1.966	270	7/16/2009	50.262	2419.6
8/13/2002	0.553	390	8/11/2009	274.047	1299.7
9/17/2002	0.332	50	8/17/2009	1198.186	2419.6
10/24/2002	0.123	140	9/23/2009	9.364	238.2
11/12/2002	0.233	80	10/27/2009	148.698	2419.6
4/15/2003	4.547	90	3/22/2010	480.503	816.4
5/14/2003	24.578	120	4/19/2010	43.749	110.6
6/17/2003	6.267	200	4/24/2010	1904.808	2419.6
7/15/2003	1.352	310	5/11/2010	2506.973	2419.6
7/29/2003	0.320	920	5/26/2010	216.288	2419.6
8/12/2003	0.049	120	6/22/2010	1536.136	1119.9
9/16/2003	6.206	550	7/13/2010	73.857	275.5
10/16/2003	0.541	60	8/11/2010	441.178	61.8
3/31/2004	131.493	410	9/21/2010	1278.065	686.7
4/21/2004	36.867	420	10/9/2010	18.802	290.9
5/19/2004	19.663	51000	6/21/2011	3084.560	25000.0

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
5/26/2004	642.719	3200	7/25/2011	25.684	54000.0
6/22/2004	40.554	300	8/15/2011	11.085	170.0
7/13/2004	320.745	4600	9/19/2011	1.057	110.0
7/20/2004	5.776	350	10/17/2011	0.172	190.0
8/17/2004	5.407	430	5/3/2012	2101.434	20000.0
9/21/2004	5.284	300	6/27/2012	24.209	300.0
10/19/2004	6.698	120	7/12/2012	0.098	1300.0
3/16/2005	17.205	36	10/23/2012	4.215	130.0
4/13/2005	2003.121	2900			
5/10/2005	14.993	100	Min =	0.01	10
6/15/2005	72.997	782	1st Quartile =	1.60	120
6/29/2005	67.098	1652	Median =	17.6	320
7/20/2005	0.909	364	3rd Quartile =	135	1300
7/28/2005	3.035	2400	Max =	3085	54000
8/25/2005	0.799	393	Mean(1) =	283	2233
9/13/2005	0.074	59	Std Dev =	628	7734

[1]For *E. coli* this is a geomean

Table C.26. Water Quality Data for IA-CHA-1328

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	0.204	10	7/28/2005	0.592	12997
4/18/2000	0.311	10	4/12/2006	0.546	95.9
5/16/2000	0.383	10	4/27/2006	0.268	44.8
6/13/2000	23.953	10	5/25/2006	13.078	1986.3
6/27/2000	162.879	1500	5/29/2008	9.102	727
7/19/2000	3.353	260	6/3/2008	118.087	1413.6
8/15/2000	1.677	680	6/16/2008	159.286	2419.6
10/17/2000	0.134	150	7/1/2008	9.916	1732.9
11/14/2000	0.311	98	7/15/2008	3.521	435.2
3/20/2001	137.729	320	8/12/2008	6.659	184.2
4/17/2001	32.815	430	9/8/2008	2.374	1553.1
5/15/2001	308.991	16000	10/27/2008	28.025	1203.3
6/1/2001	546.124	6600	11/4/2008	6.970	145
6/12/2001	9.821	200	5/14/2009	13.150	2419.6
7/11/2001	2.060	63	5/28/2009	93.176	1986.3
8/14/2001	0.115	20	6/18/2009	11.330	727.0
9/27/2001	0.230	430	6/25/2009	49.103	1732.9
10/16/2001	1.222	390	7/16/2009	9.797	648.8
11/13/2001	0.886	85	8/11/2009	53.415	1553.1
3/26/2002	4.072	10	8/17/2009	233.540	2419.6
4/16/2002	7.186	73	9/23/2009	1.825	151.5
5/14/2002	275.457	520	10/27/2009	28.983	1986.3

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
6/11/2002	7.665	900	3/22/2010	93.655	166.4
7/23/2002	0.383	250	4/19/2010	8.527	24.3
4/15/2003	0.886	10	4/24/2010	371.268	2419.6
5/14/2003	4.791	140	5/11/2010	488.637	2419.6
6/17/2003	1.222	150	5/26/2010	42.157	2419.6
7/15/2003	0.263	310	6/22/2010	299.410	1046.2
7/29/2003	0.062	3600	7/13/2010	14.396	613.1
9/16/2003	1.210	590	8/11/2010	85.991	2419.6
10/16/2003	0.105	40	9/21/2010	249.109	1986.3
5/19/2004	3.832	2500	10/9/2010	3.665	117.8
5/26/2004	125.273	910	8/15/2011	2.161	180.0
6/15/2004	467.080	2600	9/20/2011	0.172	310.0
7/13/2004	62.517	4000	10/18/2011	0.034	2100.0
7/20/2004	1.126	45000	6/27/2012	4.719	690.0
8/17/2004	1.054	81	7/12/2012	0.019	63.0
9/21/2004	1.030	50	Min =	0.019	10
10/19/2004	1.305	80	1st Quartile =	1.05	118
3/16/2005	3.353	10	Median =	6.7	435
4/13/2005	390.431	4000	3rd Quartile =	49	1986
5/10/2005	2.922	270	Max =	546	45000
6/15/2005	14.228	406	Mean[(1)] =	63	1860
6/29/2005	13.078	1370	Std Dev =	124	5396

[1]For *E. coli* this is a geomean

Table C.27. Water Quality Data for IA-CHA-1329

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	0.080	10	5/10/2005	1.152	120
4/18/2000	0.123	95	6/15/2005	5.607	3840
5/16/2000	0.151	31	6/29/2005	5.154	1920
6/13/2000	9.440	330	4/12/2006	0.215	48.7
6/27/2000	64.189	380	5/29/2008	3.587	325.5
7/19/2000	1.322	24000	6/3/2008	46.537	2419.6
8/15/2000	0.661	160	6/16/2008	62.773	365.4
10/17/2000	0.053	41	7/1/2008	3.908	238.2
11/14/2000	0.123	200	7/15/2008	1.388	67
3/20/2001	54.277	86	5/14/2009	5.182	2419.6
4/17/2001	12.932	210	5/28/2009	36.720	2419.6
5/15/2001	121.770	1600	6/18/2009	4.465	1203.3
6/1/2001	215.221	1300	6/25/2009	19.351	238.2
6/12/2001	3.870	200	7/16/2009	3.861	2419.6
7/11/2001	0.812	31	8/11/2009	21.050	816.4
8/14/2001	0.045	74	8/17/2009	92.035	2419.6

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
9/27/2001	0.091	110	9/23/2009	0.719	185.0
10/16/2001	0.481	74	10/27/2009	11.422	648.8
11/13/2001	0.349	52	3/22/2010	36.909	86.5
3/26/2002	1.605	10	4/19/2010	3.360	866.4
4/16/2002	2.832	100	4/24/2010	146.313	2419.6
5/14/2002	108.555	2100	5/11/2010	192.566	2419.6
6/11/2002	3.021	210	5/26/2010	16.614	228.2
4/15/2003	0.349	10	9/21/2010	98.171	980.4
5/14/2003	1.888	200	8/16/2011	0.902	180.0
6/17/2003	0.481	180	9/19/2011	0.081	10.0
7/15/2003	0.104	400	10/17/2011	0.013	10.0
7/29/2003	0.025	1000	6/26/2012	6.240	206.0
3/31/2004	10.100	340	7/11/2012	0.008	10.0
4/21/2004	2.832	480			
5/19/2004	1.510	6400	Min =	0.008	10
6/22/2004	3.115	670	1st Quartile =	0.46	91
7/13/2004	24.637	2600	Median =	3.0	238
7/20/2004	0.444	1200	3rd Quartile =	18	1202
8/17/2004	0.415	680	Max =	215	24000
10/19/2004	0.514	240	Mean(1) =	24	1162
3/16/2005	1.322	10	Std Dev =	48	3034
4/13/2005	153.864	2500	[1]For *E. coli* this is a geomean		

Table C.28. Water Quality Data for IA-CHA-1330

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	0.099	10	6/29/2005	5.775	2070
4/18/2000	0.146	10	3/16/2006	0.196	16.9
5/16/2000	0.178	190	4/12/2006	0.250	90.8
6/13/2000	10.569	280	4/27/2006	0.127	42.4
6/27/2000	71.820	730	5/25/2006	5.775	365.4
7/19/2000	1.487	910	5/29/2008	4.022	1553.1
8/15/2000	0.748	120	6/3/2008	52.072	2419.6
10/17/2000	0.068	31	6/16/2008	70.236	686.7
11/14/2000	0.146	750	7/1/2008	4.381	1203.3
3/20/2001	60.732	110	7/15/2008	1.561	1203.3
4/17/2001	14.477	280	8/12/2008	2.945	2419.6
5/15/2001	136.239	930	9/8/2008	1.056	1986.3
6/1/2001	240.788	1500	10/27/2008	12.365	816.4
6/12/2001	4.339	2800	11/4/2008	3.082	201.4
7/11/2001	0.917	270	5/14/2009	5.807	2419.6
8/14/2001	0.060	360	5/28/2009	41.089	1732.9
9/27/2001	0.110	1300	6/18/2009	5.004	868.6

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
10/16/2001	0.548	320	6/25/2009	21.658	1203.3
11/13/2001	0.400	350	7/16/2009	4.328	2419.6
3/26/2002	1.804	10	8/11/2009	23.559	1986.3
4/16/2002	3.177	10	8/17/2009	102.974	2419.6
5/14/2002	121.454	700	9/23/2009	0.814	2419.6
6/11/2002	3.388	7500	10/27/2009	12.787	2419.6
7/23/2002	0.178	63	3/22/2010	41.300	163.1
8/13/2002	0.057	460	4/19/2010	3.769	866.4
4/15/2003	0.400	10	4/24/2010	163.696	2419.6
5/14/2003	2.121	150	5/11/2010	215.443	2419.6
6/17/2003	0.548	430	5/26/2010	18.595	2419.6
7/15/2003	0.125	380	6/22/2010	132.015	1986.3
7/29/2003	0.036	490	7/13/2010	6.356	2419.6
8/12/2003	0.013	20	8/11/2010	37.921	2419.6
10/16/2003	0.055	40	9/21/2010	109.838	1553.1
3/31/2004	11.309	420	10/9/2010	1.625	435.2
4/21/2004	3.177	580	8/15/2011	0.962	420.0
5/19/2004	1.699	4000	9/19/2011	0.100	140.0
5/26/2004	55.240	3600	10/17/2011	0.024	270.0
6/15/2004	205.938	4000	6/26/2012	6.989	420.0
6/22/2004	3.494	2700	7/11/2012	0.017	240.0
7/13/2004	27.572	3900	10/22/2012	0.354	2800.0
7/20/2004	0.505	580			
8/17/2004	0.474	680	Min =	0.013	10
9/21/2004	0.463	2100	1st Quartile =	0.42	270
10/19/2004	0.585	460	Median =	3.13	683
3/16/2005	1.487	63	3rd Quartile =	17.6	2049
4/13/2005	172.145	1100	Max =	241	7500
5/10/2005	1.297	450	Mean[(1)] =	27	1172
6/15/2005	6.282	288	Std Dev =	53	1273

[1]For *E. coli* this is a geomean

Table C.29. Water Quality Data for IA-CHA-1332

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	2.256	41	3/16/2006	2.393	29.8
4/18/2000	2.323	140	4/12/2006	2.469	105
5/16/2000	2.368	1300	4/27/2006	2.297	23.5
6/13/2000	16.997	700	5/25/2006	10.248	770.1
6/27/2000	103.227	1100	6/7/2006	2.407	387.3
7/19/2000	4.211	3100	6/21/2006	2.167	143
8/15/2000	3.171	1500	7/27/2006	2.191	416
9/12/2000	2.242	400	8/28/2006	2.411	2420

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
10/17/2000	2.213	150	9/13/2006	2.271	1046.2
11/14/2000	2.323	300	5/29/2008	7.780	325.5
3/20/2001	87.617	110	6/3/2008	75.426	1986.3
4/17/2001	22.498	280	6/16/2008	100.997	2419.6
5/15/2001	193.918	990	7/1/2008	8.285	344.1
6/1/2001	341.103	3400	7/15/2008	4.315	579.4
6/12/2001	8.226	100	8/12/2008	6.263	1553.1
7/11/2001	3.409	710	9/8/2008	3.603	2419.6
8/14/2001	2.201	470	10/27/2008	19.525	416
9/27/2001	2.273	630	11/4/2008	6.456	62
10/16/2001	2.888	230	5/14/2009	10.292	2419.6
11/13/2001	2.680	400	5/28/2009	59.964	2419.6
3/26/2002	4.657	10	6/18/2009	9.162	547.5
4/16/2002	6.590	36	6/25/2009	32.608	344.1
5/14/2002	173.103	910	7/16/2009	8.211	866.4
6/11/2002	6.888	640	8/11/2009	35.284	1299.7
7/23/2002	2.368	870	8/17/2009	147.086	2419.6
8/13/2002	2.197	3000	9/23/2009	3.263	488.4
9/17/2002	2.170	3000	10/27/2009	20.119	1732.9
10/24/2002	2.145	4000	3/22/2010	60.261	133.4
11/12/2002	2.158	1300	4/19/2010	7.423	72.2
4/15/2003	2.680	99	4/24/2010	232.572	2419.6
5/14/2003	5.103	380	5/11/2010	305.422	2419.6
6/17/2003	2.888	70	5/26/2010	28.296	2419.6
7/15/2003	2.294	2500	6/22/2010	187.971	2419.6
7/29/2003	2.169	2800	7/13/2010	11.065	866.4
8/12/2003	2.136	1100	8/11/2010	55.503	1119.9
9/16/2003	2.881	2500	9/21/2010	156.749	1732.9
10/16/2003	2.195	260	10/9/2010	4.405	298.7
3/31/2004	18.038	270	8/15/2011	3.471	460.0
4/21/2004	6.590	200	9/19/2011	2.258	150.0
5/19/2004	4.509	5100	10/17/2011	2.151	220.0
5/26/2004	79.886	2000	4/14/2012	18.781	9200.0
6/22/2004	7.036	270	5/7/2012	72.601	8700.0
7/13/2004	40.934	4300	6/26/2012	11.957	740.0
7/20/2004	2.829	740	7/11/2012	2.142	10.0
8/17/2004	2.784	450	10/22/2012	2.616	1200.0
9/21/2004	2.769	2000			
10/19/2004	2.940	200			
3/16/2005	4.211	40	Min =	2.14	10
4/13/2005	244.466	200	1st Quartile =	2.38	245
5/10/2005	3.944	30	Median =	4.40	710
6/15/2005	10.961	1445	3rd Quartile =	19.2	1993

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
6/29/2005	10.248	1445	Max =	341	9200
7/28/2005	2.497	1733	Mean[(1)] =	33	1307
8/25/2005	2.227	6867	Std Dev =	66	1649

[1]For *E. coli* this is a geomean

Table C.30. Water Quality Data for IA-CHA-1335

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
3/28/2000	0.088	10	4/12/2006	0.236	1
4/18/2000	0.134	130	6/7/2006	0.192	1732.9
5/16/2000	0.165	10	5/29/2008	3.930	193.5
6/13/2000	10.342	370	6/3/2008	50.987	1732.9
6/27/2000	70.327	270	6/16/2008	68.776	203.5
7/19/2000	1.448	1000	7/1/2008	4.282	435.2
10/17/2000	0.058	150	7/15/2008	1.520	162.4
11/14/2000	0.134	200	8/12/2008	2.875	579.4
3/20/2001	59.468	41	9/8/2008	1.025	2419.6
4/17/2001	14.169	290	10/27/2008	12.100	980.4
5/15/2001	133.414	1400	5/14/2009	5.678	2419.6
6/1/2001	235.802	790	5/28/2009	40.231	1986.3
6/12/2001	4.240	860	6/18/2009	4.892	980.4
7/11/2001	0.889	4600	6/25/2009	21.201	435.2
8/14/2001	0.050	2500	7/16/2009	4.230	1046.2
9/27/2001	0.099	190	8/11/2009	23.063	980.4
10/16/2001	0.527	470	8/17/2009	100.836	2419.6
11/13/2001	0.383	150	9/23/2009	0.788	70.3
3/26/2002	1.758	10	10/27/2009	12.514	866.4
4/16/2002	3.103	91	3/22/2010	40.438	151.0
5/14/2002	118.935	800	4/19/2010	3.682	39.1
6/11/2002	3.309	310	4/24/2010	160.304	2419.6
7/23/2002	0.165	540	5/11/2010	210.981	2419.6
8/13/2002	0.047	54000	5/26/2010	18.202	307.6
4/15/2003	0.383	10	6/22/2010	129.277	435.2
5/14/2003	2.068	54	7/13/2010	6.216	579.4
6/17/2003	0.527	410	8/11/2010	37.128	913.9
7/15/2003	0.114	1100	9/21/2010	107.559	841.4
7/29/2003	0.027	3000	10/9/2010	1.582	1732.9
3/31/2004	11.066	310	8/15/2011	0.933	410.0
4/21/2004	3.103	2500	9/20/2011	0.074	120.0
5/19/2004	1.655	2600	10/18/2011	0.014	120.0
5/26/2004	54.090	2600	6/27/2012	2.037	910.0
6/15/2004	201.673	2200	7/12/2012	0.008	110.0
6/22/2004	3.413	190	10/23/2012	0.355	75.0

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
7/13/2004	26.993	2100			
7/20/2004	0.486	530	Min =	0.008	1
9/21/2004	0.445	80	1st Quartile =	0.40	150
3/16/2005	1.448	10	Median =	3.1	435
4/13/2005	168.578	390	3rd Quartile =	22.6	1087
5/10/2005	1.262	160	Max =	236	54000
6/15/2005	6.143	429	Mean(1) =	28	1527
3/16/2006	0.183	25.3	Std Dev =	54	6054

[1]For *E. coli* this is a geomean

Water Quality Data in Cooper Creek – Chariton River HUC 10 impaired segments

Table C.31. Water Quality Data for IA-CHA-1308

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
4/3/2000	34.627	27	11/1/2006	25.105	20
5/2/2000	26.836	140	4/2/2007	108.209	90
6/20/2000	32.896	530	5/1/2007	843.168	27
7/24/2000	38.090	170	6/4/2007	522.868	50
8/28/2000	28.567	320	7/5/2007	1099.408	20
9/12/2000	29.433	280	8/1/2007	54.018	36
10/5/2000	35.493	940	9/5/2007	882.989	60
11/9/2000	37.224	330	10/1/2007	795.556	20
4/3/2001	1393.738	10	11/5/2007	701.197	30
5/1/2001	891.646	18	4/1/2008	1566.873	450
6/6/2001	2337.324	4900	5/5/2008	780.839	30
7/3/2001	1350.454	20	6/2/2008	770.451	60
8/1/2001	858.750	30	7/9/2008	7704.514	6700
9/4/2001	39.821	140	8/6/2008	1315.827	40
10/2/2001	32.896	280	9/4/2008	1324.484	60
11/5/2001	38.955	120	4/1/2009	1376.424	10
4/1/2002	87.433	10	5/4/2009	852.691	80
5/1/2002	136.777	240	6/1/2009	792.093	98
6/3/2002	1367.768	10	7/1/2009	756.601	150
7/1/2002	232.001	140	8/3/2009	1038.811	20
8/5/2002	30.299	160	9/1/2009	803.347	98
9/4/2002	25.105	110	10/5/2009	758.332	31
10/1/2002	29.346	140	11/2/2009	882.989	110
11/5/2002	29.866	54	4/5/2010	1315.827	10
4/1/2003	30.905	10	5/3/2010	1367.768	41
5/5/2003	615.495	4500	6/1/2010	1289.857	30
6/4/2003	35.146	54	7/1/2010	1376.424	31
7/2/2003	46.314	300	8/2/2010	2605.684	41
8/4/2003	32.117	120	9/1/2010	2752.849	85
9/1/2003	42.591	200	10/4/2010	2709.565	20
10/1/2003	29.952	81	11/1/2010	943.586	30
11/3/2003	87.433	490	4/4/2011	50.209	31
4/5/2004	235.464	10	5/3/2011	456.211	41
5/3/2004	34.714	110	6/1/2011	833.646	200
6/1/2004	1220.603	2000	7/5/2011	1471.649	41
7/1/2004	691.675	81	8/1/2011	1402.395	63
8/2/2004	59.558	1200	9/1/2011	44.842	250
9/1/2004	698.600	260	10/3/2011	29.520	20
10/4/2004	109.075	100	11/2/2011	24.585	680
11/1/2004	93.493	700	4/2/2012	43.976	1200

Date	Flow (cfs)	*E. coli* (orgs/100 mL)	Date	Flow (cfs)	*E. coli* (orgs/100 mL)
4/4/2005	45.708	10	5/1/2012	98.687	960
5/2/2005	805.078	20	6/11/2012	25.797	260
6/1/2005	67.436	90	7/3/2012	23.287	130
7/6/2005	360.121	40	8/1/2012	22.075	120
8/1/2005	31.164	140	9/4/2012	22.767	120
9/6/2005	29.779	30	10/1/2012	22.334	140
10/3/2005	30.472	430	11/5/2012	23.720	120
11/1/2005	19.911	50	11/1/2006	25.105	20
4/4/2006	77.997	140	Min =	19.9	10
5/2/2006	154.090	2100	1st Quartile =	30.9	31
6/1/2006	27.442	180	Median =	96.1	98
7/3/2006	27.355	250	3rd Quartile =	857.2	200
8/1/2006	25.884	100	Max =	7704.5	6700
9/6/2006	27.355	200	Mean(1) =	585.1	354
10/2/2006	28.827	50	Std Dev =	959.4	953

[1]For *E. coli* this is a geomean

Appendix D - Flow Development

The majority of the impaired stream segments are on ungaged streams. Consequently, was necessary to estimate average daily flow rates for those segments using estimation methods.

In all cases the drainage area ratio method was used to estimate average daily flow rates. If stream gages existed on impaired streams, no estimation methods would have been needed since average daily flow rates could be read directly from the gage data. A third method was used when the effluent discharge rates from NPDES permitted facilities exceeded the estimated average daily flow rates in the stream. A brief description of each method is given below.

Drainage Area Ration (DAR)

This is a common method where average daily flows from a gaged site are transferred to an ungaged site by using the average daily flow at the reference gage multiplied by the ratio of the drainage areas of the unknown site to the reference gage.

NPDES Effluent Exceeds Estimated Stream Flow (EST)

In some cases, the aggregate effluent discharge rate from the NPDES permitted facilities within a segment reach exceeded the estimated average daily stream flow. This resulted in a load allocation less than zero in the TMDL calculation. In these cases, the average daily stream flow rates were estimated using the drainage area ratio method. After which the aggregate average wet weather flows from of the NPDES permitted facilities, located within the segment reach, and were added to the estimated daily stream flows before performing any of the load duration curve calculations. A summary of these cases is below.

Table D.1 lists each of the impaired segment, the reference gage used, method used to estimate flow rates, and the watershed that the segment is located in.

Table D.1. Summary of Flow Determinations

Waterbody	Stream Segment	Reference Gage (USGS Gage)	Method	Watershed
Chariton River	IA 05-CHA-1308	06904010	DAR	CC
Chariton River	IA 05-CHA-1310	06903400	DAR	WC
Chariton River	IA 05-CHA-1311	06903400	EST	WC
Chariton River	IA 05-CHA-1312	06903400	EST	WC
Chariton River	IA 05-CHA-1313	06903400	EST	WC
S. Fork Chariton River	IA 05-CHA-1327	06903700	DAR	SFC
S. Fork Chariton River	IA 05-CHA-1328	06903700	DAR	SFC
Walker Branch	IA 05-CHA-1329	06903700	EST	SFC
Jordan Creek	IA 05-CHA-1330	06903700	EST	SFC
Jackson Creek	IA 05-CHA-1332	06903700	EST	SFC
Ninemile Creek	IA 05-CHA-1335	06903700	EST	SFC
Honey Creek	IA 05-CHA-1337	06903400	EST	WC
Wolf Creek	IA 05-CHA-1339	06903400	DAR	WC
Fivemile Creek	IA 05-CHA-1341	06903400	DAR	WC
Honey Creek	IA 05-CHA-2019	06903400	DAR	WC

DAR - Drainage Area Ratio Method
EST - NPDES Effluent Exceeds Estimated Stream Flow
WC -Wolf Creek - Chariton River HUC-10 Watershed
SFC - South Fork Chariton HUC-10 Watershed
CC - Cooper Creek - Chariton River HUC-10 Watershed

Summary of Cases Where NPDES Effluent Exceeds Estimated Average Daily Stream Flow

Chariton River, Segment IA 05-CHA-1311, Wolf Creek - Chariton River Watershed
Table D.2 shows the estimated average daily stream flow rate using the drainage area ratio method and the adjusted average daily stream flow rate for each of the five flow regimes.

From Table C.2, the aggregate NPDES permitted facilities discharge rate is 0.0135 mgd (0.025 cfs).

Table D.2. Adjusted Midpoint Flow Rates for IA 05-CHA-1311

Flow Condition	High	Moist	Mid-Range	Dry	Low
Midpoint Flow (cfs)	96.19	5.80	1.01	0.12	0.003
Adjusted Midpoint Flow (cfs)	96.78	6.39	1.60	0.71	0.59

Chariton River, Segment IA 05-CHA-1312, Wolf Creek - Chariton River Watershed
Table D.3 shows the estimated average daily stream flow rate using the drainage area ratio method and the adjusted average daily stream flow rate for each of the five flow regimes.

From Table C.3, the aggregate NPDES permitted facilities discharge rate is 0.271 mgd (0.50 cfs).

Table D.3. Adjusted Midpoint Flow Rates for IA 05-CHA-1312

Flow Condition	High	Moist	Mid-Range	Dry	Low
Midpoint Flow (cfs)	96.19	5.80	1.01	0.12	0.003
Adjusted Midpoint Flow (cfs)	96.78	6.39	1.60	0.71	0.59

Chariton River, Segment IA 05-CHA-1313, Wolf Creek - Chariton River Watershed
Table D.4 shows the estimated average daily stream flow rate using the drainage area ratio method and the adjusted average daily stream flow rate for each of the five flow regimes.

From Table C.4, the aggregate NPDES permitted facilities discharge rate is 0.012 mgd (0.022 cfs).

Table D.4. Adjusted Midpoint Flow Rates for IA 05-CHA-1313

Flow Condition	High	Moist	Mid-Range	Dry	Low
Midpoint Flow (cfs)	96.19	5.80	1.01	0.12	0.003
Adjusted Midpoint Flow (cfs)	96.78	6.39	1.60	0.71	0.59

Walker Branch, Segment IA 05-CHA-1329, South Fork Chariton River Watershed
Table D.5 shows the estimated average daily stream flow rate using the drainage area ratio method and the adjusted average daily stream flow rate for each of the five flow regimes.

From Table C.8, the aggregate NPDES permitted facilities discharge rate is 0.001 mgd (0.002 cfs).

Table D.5. Adjusted Midpoint Flow Rates for IA 05-CHA-1329

Flow Condition	High	Moist	Mid-Range	Dry	Low
Midpoint Flow (cfs)	96.19	5.80	1.01	0.12	0.003
Adjusted Midpoint Flow (cfs)	96.78	6.39	1.60	0.71	0.59

Jordan Creek, Segment IA 05-CHA-1330, South Fork Chariton River Watershed
Table D.6 shows the estimated average daily stream flow rate using the drainage area ratio method and the adjusted average daily stream flow rate for each of the five flow regimes.

From Table C.9, the aggregate NPDES permitted facilities discharge rate is 0.005 mgd (0.009 cfs).

Table D.6. Adjusted Midpoint Flow Rates for IA 05-CHA-1330

Flow Condition	High	Moist	Mid-Range	Dry	Low
Midpoint Flow (cfs)	122.0	7.4	1.3	0.147	0.004
Adjusted Midpoint Flow (cfs)	122.04	7.36	1.29	0.16	0.013

Jackson Creek, Segment IA 05-CHA-1332, South Fork Chariton River Watershed
Table D.7 shows the estimated average daily stream flow rate using the drainage area ratio method and the adjusted average daily stream flow rate for each of the five flow regimes.

From Table C.10, the aggregate NPDES permitted facilities discharge rate is 1.15 mgd (2.13 cfs).

Table D.7. Adjusted Midpoint Flow Rates for IA 05-CHA-1332

Flow Condition	High	Moist	Mid-Range	Dry	Low
Midpoint Flow (cfs)	171.8	10.4	1.8	0.21	0.01
Adjusted Midpoint Flow (cfs)	173.9	12.5	3.9	2.3	2.1

Ninemile Creek, Segment IA 05-CHA-1335, South Fork Chariton River Watershed
Table D.8 shows the estimated average daily stream flow rate using the drainage area ratio method and the adjusted average daily stream flow rate for each of the five flow regimes.

From Table C.11, the aggregate NPDES permitted facilities discharge rate is 0.004 mgd (0.007 cfs).

Table D.8. Adjusted Midpoint Flow Rates for IA 05-CHA-1335

Flow Condition	High	Moist	Mid-Range	Dry	Low
Midpoint Flow (cfs)	171.8	10.4	1.8	0.21	0.01
Adjusted Midpoint Flow (cfs)	173.9	12.5	3.9	2.3	2.1

Honey Creek, Segment IA 05-CHA-1337, Wolf Creek - Chariton River Watershed
Table D.9 shows the estimated average daily stream flow rate using the drainage area ratio method and the adjusted average daily stream flow rate for each of the five flow regimes.

From Table C.5, the aggregate NPDES permitted facilities discharge rate is 0.310 mgd (0.58 cfs).

Table D.9. Adjusted Midpoint Flow Rates for IA 05-CHA-1337

Flow Condition	High	Moist	Mid-Range	Dry	Low
Midpoint Flow (cfs)	96.19	5.80	1.01	0.12	0.003
Adjusted Midpoint Flow (cfs)	96.78	6.39	1.60	0.71	0.59

Appendix E - DNR Project Files and Locations

This appendix is primarily for future reference by DNR staff that may wish to access the original spreadsheets, models, maps, figures, and other files utilized in the development of the TMDL.

Table E.1. Project Files and Locations

Directory\folder path	File name	Description
\\iowa.gov.state.ia.us\data\DNR_WQB_WIS_TMDL\Draft_TMDLs\UpperChariton-R_00\Data\Raw	Bacteria Data.XLS	General Summary of all stream segments. Includes tabs with WQ Data for each stream organized by stream segment and data collection site.
\\iowa.gov.state.ia.us\data\DNR_WQB_WIS_TMDL\Draft_TMDLs\ UpperChariton-R_00\Data\Reduced	Various files, File Type: .XLS Example: "1308_Flows Upper Chariton River". This is the stream flow calculation for stream segment IA 05-CHA-1308 on the Chariton River. Some files have WQ Data collection location listed which indicates WQ data was only collected at one site on the segment. If no site is listed, WQ data was collected at multiple sites on the stream segment.	Stream Segment Flow Calculation spreadsheets. The flow calculations are organized by HUC-8 watersheds and subdivided by stream and subdivided by stream segment.
\\iowa.gov.state.ia.us\data\DNR_WQB_WIS_TMDL\Draft_TMDLs\ UpperChariton-R_00\Modeling\LDC	Various files, File Type: .XLS Example 1: "IA 05-CHA-1308 LDC". This is the LDC for stream segment IA 05-CHA-1308 on the Chariton River.	Load Duration Curve spreadsheets. The LDC's are organized by HUC-10 watersheds and subdivided by stream within the listed directory.
\\iowa.gov.state.ia.us\data\DNR_WQB_WIS_TMDL\Draft_TMDLs\ UpperChariton-R_00\Modeling\NPDES	Various files, File Type: .XLS Example: "WLA Cooper". This is the WLA for the Cooper Creek - Chariton River HUC 10 watershed.	Waste Load Allocation spreadsheets. The WLA's are organized by HUC-10 watersheds. .
\\iowa.gov.state.ia.us\data\DNR_WQB_WIS_TMDL\Draft_TMDLs\ UpperChariton-R_00\Data\Weather	Various files, File Type: .XLS Example: "Precip.XLS". This is precipitation data for the Lower Iowa HUC-10.	Weather Data. 3 separate files exist for each HUC-10 watershed within the Upper Chariton River watershed.
\\iowa.gov.state.ia.us\data\DNR_GIS_Data\NASS\National_cropland_data_layer\CDL_2014\03RECODE\Grids. (Location of original file)	cdl2014rc, Raster File	National Crop Land Layer. This was used to generate Land Use Coverage data and statistics.

Directory\folder path	File name	Description
\\iowa.gov.state.ia.us\data\DNR_WQB_WIS_TMDL\Draft_TMDLs\UpperChariton-R_00\Data\Land_Use	Combined LandUse.XLS	Land Use Statistics. The spreadsheet has a separate tab for each HUC-10 watershed in the Upper Chariton River watershed.
\\iowa.gov.state.ia.us\data\DNR_WQB_WIS_TMDL\Draft_TMDLs\UpperChariton-R_00\GIS\GIS_Data	Various shapefiles (.shp) and raster files (.grd)	Used to develop models and maps.
\\iowa.gov.state.ia.us\data\DNR_WQB_WIS_TMDL\Draft_TMDLs\UpperChariton-R_00\Documents, Presentations\References	Various .pdf and .doc files	References cited in the WQIP and/or utilized to develop model input parameters
\\iowa.gov.state.ia.us\data\DNR_WQB_WIS_TMDL\Draft_TMDLs\UpperChariton-R_00\GIS\GIS_Data	Various shapefiles (.shp) and raster files (.grd)	Used to develop models and maps
\\iowa.gov.state.ia.us\data\DNR_WQB_WIS_TMDL\Draft_TMDLs\UpperChariton-R_00\Data	Various Files Various File Formats	Raw data collected from various sources used to develop the report.

Appendix F - Public Comments

Public Comment:

All public comments received during the public comment period will be placed in this section, along with Iowa DNR responses.